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Foreword

The Symposium of Agricultural Economists with international participation was held at the Faculty of Agriculture in Zemun on 21 and 22 September 2023. The reason for this meeting was the celebration of an important anniversary - 60 years of existence and work of the Department of Agricultural Economics at the Faculty of Agriculture of the University of Belgrade.

The meeting received registrations for 33 papers, featuring contributions from both Serbia and abroad. Scientists from the following institutions participated in the work of the Symposium: Ministry of Environmental Protection of the Republic of Serbia, Ministry of Rural Welfare of the Republic of Serbia, Faculty of Agriculture of the University of Belgrade (Serbia), Faculty of Agriculture of the University of Novi Sad (Serbia), Faculty of Agriculture in Kruševac of the University of Niš (Serbia), Institute for Animal Husbandry in Belgrade (Serbia), Maize Research Institute "Zemun Polje" in Belgrade (Serbia), Institute of Agricultural Economics in Belgrade (Serbia), Faculty of Organisational Sciences of the University of Belgrade (Serbia), Institute for Science Application in Agriculture in Belgrade (Serbia), Faculty of Economics in Subotica of the University of Novi Sad (Serbia), Novi Sad School of Business (Serbia), Academy of Applied Technical Studies in Belgrade (Serbia), Toplica Academy of Applied Studies (Serbia), Faculty of Agriculture of the University of Banja Luka (Republic of Srpska), Faculty of Agriculture of the University of East Sarajevo (Republic of Srpska), Faculty of Agriculture of the University of Bijeljina (Republic of Srpska), Faculty of Agriculture of the University of Zagreb (Croatia), Faculty of Agricultural Science and Food of the University "St. Cyril and Methodius" (North Macedonia), Faculty of Agriculture and Life Sciences of the University of Maribor (Slovenia), Volgograd State Agricultural Academy (Russia), Bucharest University of Economic Studies (Romania), Faculty of Agricultural Management, Banat University of Science and Veterinary Medicine in Timişoara (Romania), Leibniz Institute of Agricultural Development in

Transition Economies (IAMO) in Halle (Germany), as well as representatives of the Auto-Moto Association of Serbia (Serbia), Dnevnik-poljoprivrednik from Novi Sad (Serbia) and certification body "Eco Vivendi" (Serbia).

In addition to the scientific staff of the above-mentioned institutions, the Symposium was also attended by numerous business people, teachers from agricultural secondary schools, individual agricultural producers and students.

The main objective of the Symposium was to exchange the latest theoretical and empirical research results and experience in solving problems of agriculture and the food industry within the agro-industrial complex that directly or indirectly affect rural development and food production.

The papers published in these Proceedings are intended to contribute to the understanding of certain problems that exist in the agribusiness industry in our country and in the world, and to offer solutions to these problems.

Editor
Dr Dragić Živković
Retired Full Professor

C o n t e n t s

Smart Villages - Concepts and Approaches

Grujica VICO[1], Danijel MIJIĆ[2], Radomir BODIROGA[3]

Abstract

In the age of digital transformation, the emergence of Smart Villages is revolutionizing rural development. This paper focuses on different aspects of smart villages with the aim to give an overview of the concept of smart villages as well as the importance of smart villages in rural development. The research covers different definitions and concepts of smart villages, dimensions and elements, as well as challenges and benefits. Key initiatives, policies and practices around the world are listed and briefly explained in the text. Smart Villages integrate a range of digital tools, from high-speed internet and IoT to AI and mobile applications, into various aspects of rural life. Smart Villages offer a promising future for rural areas, combining tradition with innovation to improve the lives of residents in an increasingly digital world. As Smart Villages continue to evolve, they will play a pivotal role in rural development, offering new opportunities and an improved quality of life for all.

Keywords: digitalization, rural communities, concept, innovation, development

Introduction

One of the components of digital revolution is the advent of digital agriculture, often referred to as precision farming or smart farming. Digital agriculture offers a wide range of solutions to some agricultural challenge and it is seen as a potential solution for improving sustainability of agri-food systems, increasing the productivity, efficiency, while decreasing costs of production and negative impact on environment (Mijic et al, 2023). Digital

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technologies enable farmers to make data-driven decisions that optimize crop production, reduce resource wastage, and enhance agricultural sustainability. Through sensors, drones, and satellite imagery, farmers can monitor soil conditions, crop health, and weather patterns in real-time. Machine learning algorithms analyze this data to provide insights that empower farmers to apply precisely the right amount of water, fertilizer, and pesticides, resulting in increased yields and reduced environmental impact.

OECD (2018) provides an overview of key digital technologies used in agriculture, such as: Platforms: compare information and promote wider access to, and more efficient use of, a range of information and services. These platforms enable commercial and non-commercial transactions in B2B, B2C, and C2C markets; Sensors: according to the *Wilson (2008*) they can be defined as "the interface between the physical world and the world of electrical devices, such as computers"; Internet of Things (IoT): According to the ITU recommendations, IoT means the global infrastructure which enables advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies. IoT involves the deployment of interconnected sensors and devices in the field, enabling real-time data collection and analysis. Farmers can monitor soil moisture levels, weather conditions, and crop health remotely, allowing for precise irrigation, pest management, and resource allocation; Robotics and drones: robots are small-sized automatic machines that can substitute traditional agricultural machinery in different farm activities. Drones, also known as unmanned aerial vehicles (UAV), can support the application of precision agriculture techniques. UAV allows to obtain images of large agricultural areas and gather information about soil quality and plant diseases; Big data: ICTs, including the Internet, as well as connected sensors capturing the physical world are increasingly leveraging large volumes of digital data. These large streams of data, and the capacity to combine them, are referred to as "big data"; Cloud computing: Cloud computing offers the capacity required for data storage and data integration. In this way, cloud computing supports big data analytics; Artificial intelligence (AI): AI or cognitive-based technologies help computers interact, reason, and learn like human beings to enable them to perform a broad variety of cognitive tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages and demonstrating an ability to move and manipulate objects accordingly; Blockchain: is a distributed database, replicated across many locations and operated jointly by all users. The integration of ICT technologies into agriculture represents a transformative shift in the industry. These innovations empower farmers with data-driven insights, improve resource management, reduce environmental impact, and ultimately contribute to the sustainability and resilience of the global food supply chain. The adoption of these ICT tools holds the promise of addressing the challenges of feeding a growing global population while optimizing resource use.

Recent smart village initiatives represent a new phase of rural development and the agriculture sector and include the implementation of all forms of digital technologies.

The aim of this paper is to give an overview of the concept of smart villages as well as the importance of smart villages in rural development. Also, this paper describing the essential elements of smart villages, such as technology, infrastructure, and community engagement and how these components contribute to the development of smart villages.

The concept of smart villages

Digital transformation, at its core, involves the integration of digital technologies into various aspects of society, including governance, education, healthcare, agriculture, and infrastructure. It encompasses a wide spectrum of technologies, such as high-speed internet, data analytics, the IoT, AI, and mobile applications. These tools enable the collection, analysis, and dissemination of data, fostering innovation and efficiency in diverse sectors.

Smart villages, on the other hand, represent a holistic approach to rural development that leverages digital transformation. They are more than just technological upgrades; they are about empowering communities to take control of their destinies by harnessing the potential of these digital tools. Given that there are several parallel initiatives to create smart villages, we also find several definitions that are more or less similar with minor differences. The EU defines smart villages as "rural areas and communities that build on their existing strengths and assets to develop new opportunities through place-based strategies, bringing together innovative solutions, enabling participation, and improving the delivery of services. Smart villages enhance the quality of life, foster resilience, and economic and social development in rural areas”. Food and Agriculture Organization (FAO) defines smart villages as "rural communities that utilize a wide range of digital technologies and innovations to improve agricultural practices, access to markets, social services, and overall quality of life". The World Bank defines smart villages as "rural communities that leverage information and communication technologies (ICTs) to enhance agricultural productivity, access to education and healthcare, local governance, and economic opportunities". International Telecommunication Union (ITU) defines smart villages as "rural communities that leverage telecommunications and digital technologies to improve livelihoods, education, healthcare, and governance". All of these definitions highlight common themes of using technology, innovation, and community engagement to improve rural development, but may vary slightly in emphasis and terminology depending on specific organizational goals and areas of focus.

Smart villages, represent a holistic approach to rural development that leverages digital transformation. They are more than just technological upgrades; they are about empowering communities to take control of their destinies by harnessing the potential of these digital tools. Key elements of smart villages include:

1. Digital Infrastructure: Smart villages prioritize the development of robust digital infrastructure, including high-speed broadband connectivity, which serves as the backbone for access to digital services.
2. Agricultural Innovation: Digital technologies are employed to improve agricultural practices, from precision farming and remote monitoring to market access and supply chain management.
3. Education and Healthcare: Digital tools facilitate remote learning and telemedicine, ensuring that residents in remote areas have access to quality education and healthcare services.
4. Entrepreneurship: Smart villages encourage entrepreneurship by fostering innovation hubs and supporting local businesses through e-commerce and digital marketing.
5. Community Engagement: The involvement of the community is central to the success of smart villages. Participatory decision-making processes and citizen engagement platforms enhance governance and accountability.
6. Sustainability: Smart villages prioritize environmental sustainability by promoting renewable energy, efficient resource use, and eco-friendly practices.

As smart village is a holistic concept with an extremely broad scope, it is difficult to make a single classification of all dimensions. There is a large number of classifications in the literature and in practice. Describing the conceptual model of a smart village Mishbah et al. (2018) include seven dimensions: energy, economy, ICT, people, governance, environment and living. Smart village digital ecosystem includes society, digital service, technical platform, infrastructure and organizational ecosystem (Philip and Wiliams, 2019). Zhang and Zhang (2020) provides the theoretical framework for a smart village system with five subsystems: the strategic subsystem, the social subsystem, the economic subsystem, the information subsystem and the resource and environmental subsystem. Six dimensions of the smart village concept as follow: management, quality of life, economy, society, natural environment and mobility are identified by some researchers (Guzal-Dec et al. 2019, Adamowicz and Zwolinska-Ligaj, 2020). Subliming different approaches, Wang et al. (2022) include eight dimensions (Figure 1)

Figure 1. Dimension and elements of the smart village concept

Society	• Human capital, cultural capital, institutions, knowledge, information, innovation, etc
Resources	• Energy, land, water, soil, air, etc
Infrastructure	• Architecture, transportation, waste and water management, power grid, telecommunication, etc.
Economy	• Agriculture, farming, tourism, e-commerce, creative industry, etc.
Governance	• Decision making, planning, monitoring, assessment, e-governance, branding, etc
Service	• Sanitation, employment, health care, education, food supply, safety, housing, training, etc.
Technology	• IoT, AI, cloud, blockchain, GIS, computing, smart grid, 5G, ICTs, etc
Others	• Strategies, objectives, challenges, conditions, etc

Source: Wang et al., 2022

Challenges and benefits of smart village concept

Smart villages, while promising in terms of rural development and sustainability, face several key challenges that need to be addressed for their successful implementation. Key challenges can be identified through the universal characteristics of rural areas. Key challenges can be identified through the universal characteristics of rural areas. There is a limited healthcare infrastructure, including healthcare centers, hospitals, and specialized practitioners in rural areas (Mars, 2013). People need to travel long distances to get health care (Awoyemi et al. 2011). Assuring high-quality educators in rural areas is becoming more and more challenging because (Pateman, 2011). Business experience, knowledge, high qualifications, and technology skills usually are not available within rural regions. Migration of skilled people and young workers and the generally underdeveloped job market contribute to generating economic pressure and depression in rural areas (Mendola, 2012). Summarizing research and practices, it is possible to identify several key challenges in the process of creating digital villages. Some of them are:

Digital Divide: Unequal access to digital infrastructure and technology can create a significant digital divide between urban and rural areas. Ensuring reliable high-speed internet access in remote regions is a critical challenge, as it forms the foundation for most smart village initiatives. Lack of Digital Literacy: Rural communities may lack the necessary digital skills and literacy to effectively use technology. Bridging this gap is essential to ensure that residents can fully benefit from digital services and opportunities; Resource Constraints: Many rural areas have limited financial and human resources for implementing smart village projects. Funding constraints can hinder the development of necessary infrastructure and the adoption of advanced technologies; Infrastructure Development: Building the required digital and physical infrastructure, including broadband networks, energy grids, and transportation systems, can be costly and time-consuming, particularly in remote areas with challenging terrain; Sustainability: Balancing economic growth with environmental sustainability is a challenge. Smart villages must implement sustainable practices to avoid harming the natural environment through increased resource consumption and pollution; Cultural and Social Considerations: Integrating technology and modern practices into traditional rural communities may face resistance or require careful consideration of cultural norms and values; Dependency on Technology: Overreliance on technology can lead to vulnerabilities in case of system failures or cyberattacks. Backup plans and resilient systems are necessary to mitigate these risks; Policy and Regulatory Barriers: Inconsistent or outdated policies and regulations can hinder the deployment of innovative technologies and services in rural areas. Governments need to adapt and create an enabling environment for smart village development; Community Engagement: Ensuring active community involvement and buy-in for smart village initiatives can be challenging. Residents need to see the benefits of these projects and actively participate in their implementation; Socioeconomic Inequalities: Smart villages must address socioeconomic disparities within rural communities. Projects should strive to benefit all residents, regardless of income level or social status; Scalability: Scaling successful smart village models from small pilot projects to broader regions can be challenging due to the need for additional resources and infrastructure and Interconnectedness: Coordinating various stakeholders, including government agencies, NGOs, and private sector partners, to work together effectively can be complex but is crucial for holistic smart village development.

On the other hand, there are a large number of benefits that digital villages bring. In an increasingly digital world, smart villages are emerging as beacons of hope for rural communities worldwide. These innovative, technology-driven initiatives are transforming rural landscapes and improving the quality of life for residents in myriad ways. The benefits of smart villages are multifaceted, and they hold the promise of addressing longstanding challenges while fostering sustainability and resilience. Smart villages contribute to inhabitants' access to modern energy sources, basic education and health care, and food security (Holmes and Tomas, 2015, Homes and Van Gevelt, 2015). The development of smart villages can also help facilitate access to public e-services, environmental protection, circular economy, high level productivity of agricultural production, smart specialization in different fileds, such as tourism, cultural activities etc. (Zavratnik et al, 2018, Komorowski and Stanny, 2020). It is undeniable that smart villages bring many benefits to the inhabitants of rural communities, where several key areas can be identified:

- *Economic Empowerment:* smart villages stimulate economic growth by promoting entrepreneurship and local business development. Innovative agricultural practices and precision farming techniques enhance crop yields, providing a sustainable source of income for farmers.

- *Quality Education:* Digital technologies enable distance learning and e-learning opportunities, ensuring that students in remote areas have access to quality education.
- *Enhanced Agricultural Practices:* Precision agriculture, guided by data from IoT sensors and drones, optimizes resource use and minimizes environmental impact. Farmers receive real-time weather forecasts and expert advice, leading to increased crop yields and sustainable farming practices.
- *Connectivity and Communication:* High-speed internet access enables seamless communication among community members and with the outside world. Digital platforms foster social cohesion and civic engagement, strengthening community bonds.
- *Environmental Sustainability:* Smart villages prioritize sustainable practices, including renewable energy adoption and efficient resource management. Reduced resource consumption, eco-friendly agriculture, and green infrastructure contribute to environmental preservation.
- *Resilience and Disaster Preparedness:* IoT sensors and early warning systems aid in disaster preparedness and response, safeguarding communities against natural calamities. Advanced forecasting helps farmers protect their crops and livestock

Key initiatives and actions

Taking into account the heterogeneity at the global level in different aspects, such as economic, social, cultural, political, it is realistic to expect that there are different practices and policies for the creation of smart villages. While in some parts of the world a bottom-up approach is accepted, in other parts a top-down model is practiced. Such an approach is accepted in China and it is determined by China's political and economic system (Zhang and Zhang, 2020). The Chinese government proposed the implementation of the Rural Revitalization Strategy in 2017 and formulated the “National Rural Revitalization Strategic Plan (2018–2022)” in 2018, and the “Outline of the Smart Village Development Strategy” in 2019. where they noted "Based on the national and agricultural conditions in the new era, it is necessary to take the digital village as an important aspect of building digital China, accelerate the development of informatization, and encourage and improve the modernization of agriculture and rural areas” (Central Committee of the Communist Party of China, 2019). These plans intend to achieve sustainable development in rural areas by promoting informatization in various fields of villages.

IEEE Smart Village (ISV) provides a catalyst for development in disadvantaged communities around the globe by providing technical and financial support to local entrepreneurs who expand access to both energy and education to remote communities (Mackenzie, 2019). The mission of ISS is to "integrate sustainable electricity, education, and entrepreneurial solutions to empower off-grid communities". The initiative consists of three key pillars: energy, education and entrepreneurship, with a vision aimed at equal access to electricity and education for all people.

The concept of "smart villages" in the EU has involved numerous discussions, analysis and researches in recent years and has generated reports, policy documents and guidelines (Figure 2).

Figure 2. Timeline of the key EU activities for smart villages

"EU Action for Smart Villages" was launched in 2017, approved by the EU Commissioner for Agriculture, Rural Development, Cohesion Policy and Mobility and Transport. In order to achieve a common understanding of the concept in 2017, a Thematic Group for Smart Villages was established by the Contact Point of the European Network for Rural Development (ENRD). In 2018, a pilot project of smart eco-social villages was launched with the aim of defining smart villages at the EU level. The 'Preparatory Action on Smart Rural Areas in the 21st Century' (Smart Rural 21) project was a two and a half-year project supported by the European Commission (DG AGRI) with the overall aim to promote and inspire villages to develop and implement smart village approaches and strategies across Europe. The '2nd Preparatory Action on Smart Rural Areas in the 21st Century' (Smart Rural 27 project) was launched by the European Commission in December 2020 with the aim to "prepare Member States and rural communities for the implementation of the Common Agricultural Policy (CAP) post-2020 as well as other EU policies and initiatives, which could potentially support the emergence of additional Smart Villages across the European Union".

FAO launched the Digital Village Initiative (DVI) to promote digital innovations to support inclusive, gender sensitive rural development and sustainable agri-food transformation in support of Agenda 2030. FAO DVI follows a country-led, user-centered, holistic digital ecosystem approach for digital village development.

Conclusion

In an era where digital transformation reshapes every facet of our lives, rural communities are not left behind. The emergence of Smart Villages represents a beacon of hope for rural development, marrying traditional values with the power of digital technologies. These innovative initiatives are more than just technological upgrades; they embody a holistic approach to rural development. Smart Villages leverage a spectrum of technologies, from high-speed internet and data analytics to IoT, AI, and mobile applications. These tools empower rural communities to harness the potential of digital transformation and take control of their destinies. While definitions may vary, they all share a common goal: using technology, innovation, and community engagement to improve rural development. The key elements of Smart Villages encompass digital infrastructure, agricultural innovation, education, healthcare, entrepreneurship, community engagement, and sustainability. These elements work in synergy to enhance the quality of life for rural residents, fostering resilience and economic growth. However, Smart Villages also face challenges, such as the digital divide, lack of digital literacy, resource constraints, and policy barriers. Overcoming these hurdles requires concerted efforts from governments, NGOs, and local communities. The benefits of Smart Villages are undeniable. They stimulate economic growth, provide access to quality education and healthcare, optimize agricultural practices, strengthen community bonds, promote environmental sustainability, and enhance disaster preparedness. Key initiatives and actions around the world demonstrate the diverse approaches to creating Smart Villages. Whether through top-down government-driven strategies or bottom-up community-led efforts, the goal remains the same: to bridge the rural-urban divide and empower rural communities through digital transformation. In conclusion, Smart Villages represent a promising path toward a brighter future for rural areas. They embody the fusion of tradition and innovation, offering a lifeline for rural communities in an increasingly digital world. As we look ahead, the evolution of Smart Villages will continue to shape the landscape of rural development, offering new opportunities and improved quality of life for all.

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Gross Ecosystem Product - Indicator of Economy 4.0

Radmilo V. PEŠIĆ[4]

Abstract

Gross ecosystem product (GEP) is a measure of the contribution that the environment, and the ecosystems included in it, provide to the human well-being and social progress. The necessity of introducing natural capital into macroeconomic calculations was noticed during the second half of the twentieth century. Since then, a great effort to create ecological-economic indicators, has been made, with an aim to support the achievement of global sustainability. At the beginning of the 21st century, owing to innovations of the fourth scientific, technical and industrial revolution, the prerequisites, as well as the needs, for new, complex indicators are created, including the GEP and the Green Development Index (GDI) based on it. Today these indicators are mostly used in China, but interest in them is growing around the world. Unfortunately, there has been no attempt to monitor GEP and GDI in Serbia. This paper is intended to inform the professionals in Serbia with the global trends in the field.

Keywords: Fourth scientific and technical revolution, macroeconomic accounts, Gross Ecosystem Product, Green development index

Introduction

The fourth scientific industrial and technical (r)evolution is considered the biggest global change in the economy and society in the 21st century. On the basis of technological improvements, which enabled changes in production, marketing and consumption at the end of the 20th century, a wide front of improvements in almost all processes, from agriculture and mining, through industry and trade, to telecommunications and financial services, has been initiated. Today, there is a lot of evidence that we are faced not only with the Industry 4.0, but with the entire Economy 4.0, based on digitalization, artificial intelligence, robotics, network communication,

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and large data management. The key features of Economy 4.0 are: efficiency, efficacy, transparency, pro-activity, minimization of waste in resources, materials, energy, products and time, with a constant care for the environment and its carrying capacity. The essential changes that 4.0 brings are primarily of a microeconomic nature, but cumulatively they create essentially determining effects on the macroeconomics. In order to monitor macro-effects of the Economy 4.0, and to adapt social processes to the technological changes, new economic indicators are needed. In that sense, one of the most complex and computationally demanding macro-indicators, the Gross Ecosystem Product (GEP) has been created as a supplement to the existing ecological-economic accounts. In the first part of the paper, the development of macroeconomic accounts, as well as the creation of a system of ecological-economic accounting has been presented. The second, central part of the paper is dedicated to the Gross Ecosystem Product. The third part is focused on the Green Development Index (GDI), an indicator based on the Gross Ecosystem Product and its potential applications in strategic and development decisions.

Genesis and evolution of macroeconomic accounts

The first attempts to establish national economy accounting systems are related to the early thirties of the 20th century, mostly to the ideas of an American economist of Russian origin, Simon Kuznets. Interrelated indicators of business activity in a number of developed countries served as a tool of economic analysis in the years after the Great Depression. Conducting active stabilization macroeconomic policies required complex information bases, which were offered by the first systems of national accounts, implemented in Great Britain, USA, Norway, France and the Netherlands (Pešić, 2020).

Summarizing the prewar knowledge on the creation and use of these accounts, Richard Stone published a monograph on macroeconomic accounting in 1946. His study laid the ground for further progress. A few years later, the Organization for European Economic Cooperation (OEEC) developed an integral system of national accounting (SNA) which, with minor changes, was also adopted by the United Nations in 1953. The system was revised in 1968. The input-output tables were introduced, as well as the financial transaction balances, later integrated with formation and use of the Gross Domestic Product tables (United Nations, 1968).

However, even in the early fifties, it was clear that the proposed system of macroeconomic aggregates and national accounts did not properly reflect an impact that the environment and natural resources have on social welfare and income (Kapp, 1950). Considering the fact that the system of National Accounts (SNA) was created during the so-called years of pan-technological optimism, when an insufficient attention to resource depletion was paid, it is not surprising that in the Gross Domestic Product, in the National Income, and in the National Wealth calculations, a real contribution of life and natural environment to the economic development was omitted (Pešić, 2020).

Critical objections to the SNA may be grouped into three points (Perman, Ma and McGilvray, 1996). The first is ignoring of natural capital, and a focus on technical or man-made capital in calculations of the Social Wealth. Natural funds, e.g. forests that can be exploited, or fish that can be caught, ores of metals and nonmetals, and other resources, e.g. clean air and water, wildlife habitats, along with everything else that is not subject to the market exchange, are simply left out.

From this deficiency emerge another, which was reflected in an omission of natural resource depreciation. When calculating the Net Product and the National Income, the amount of depreciation is subtracted from the value of the Gross Product, but only the depreciation of technical capital, while the depreciation of natural capital is not taken into consideration, which leads to an unrealistically augmented value of the Net Product. This is particularly evident in countries with an economic structure dominated by natural resource extraction, mostly underdeveloped countries (Pešić 2020).

The third weakness of the conventional SNA stems from an inconsistent treatment of environmental protection costs. The fact is that costs of protecting, preserving, and improving the environment, the so-called "defensive costs", are included in the National Income calculation. However, since the costs of natural depletion are not taken into account, investments in improving the environment are not reported as an increase in the National Wealth, which also contribute to the unrealistic image (Pešić 2020).

Theoretical criticism, during the seventies of the 20th century, led to a reexamination of the SNA conceptual framework. In 1974, the UN Statistical Office initiated a long-term effort on the environmental data (United Nations 1975, 1976, 1977a, 1977b). As an outcome, a significant methodological study appeared (United Nations 1984), accepted by the UN

Environment Programme. On the basis of the study, in 1993, a comprehensive Manual for keeping national environmental and economic accounts was created (SEEA, 1993). This Manual represents a turning point in the development of environmental macro-accounting. The point was in adjustment of the existing accounts, through the so-called "greening" of macroeconomic aggregates, Gross Domestic Product, and the Gross National Product. After almost ten years of the Manual implementation, in a number of countries based on numerous experiences, the UN Statistics Office issued a new, improved version of the SEEA in 2003. Meanwhile, the number of countries that have decided to implement the SEEA has increased. The number of international organizations that have supported the activities has also increased, including the World Bank, IMF, FAO, OECD and the European Commission, which has strengthened further efforts to improve SEEA. Thus, in 2014, a comprehensive study was published under the title *System of Environmental-Economic Accounting 2012* (United Nations, 2014). It provides the broadest methodological basis for further efforts in the green macroeconomics, in terms of achieving global sustainability in the course of the fourth scientific and technical revolution.

Gross Ecosystem Product

As part of efforts to express the contribution of the environment to humanity in economic terms, as adequately as possible, the concept of the Gross Ecosystem Product was created. In its creation, in addition to the American economists from the Stanford University and the University of Minnesota, a key role was played by the Chinese economists gathered around the Chinese Academy of Sciences. Initial ideas that gave rise to the concept of the Gross Ecosystem Product were born in the mid-eighties of the 20th century, in the writings of an ecological economist Hannon (1985). These writings presented an attempt to estimate monetary values of the ecosystem “services”, i.e. contribution of the environment to economic development and human existence in general. Estimations of the value of ecosystem services have also been explored by the numerous economists in other parts of the world (Hanley, Barbier, 2009), (Kubiszevski et al., 2016). As a result, a database on ecosystem service prices has been established (De Groot et al., 2012). However, a full credit for affirmation of the Gross Ecosystem Product, and the Green Development Index, derived from it, belongs to the Chinese scientists. In 2013, Ouyang and Zhu proposed a new concept of the GEP. They defined it as a sum of final production plus value of services that ecosystems provide to human well-being and development. (Haijiang Yang et al., 2023) When it comes to the total ecosystem services, regulatory services, cultural services and supporting services are analyzed within the GEP concept (Chaozhi Hao et al., 2022). The Gross Ecosystem Product is calculated in a form of value stream for a certain territory, in a period of one year, as the sum of the value of ecosystem products (EPV), regulation ecosystem services (ERV), the value of ecosystem cultural services (ECV), and the value of ecosystem support (ESV).

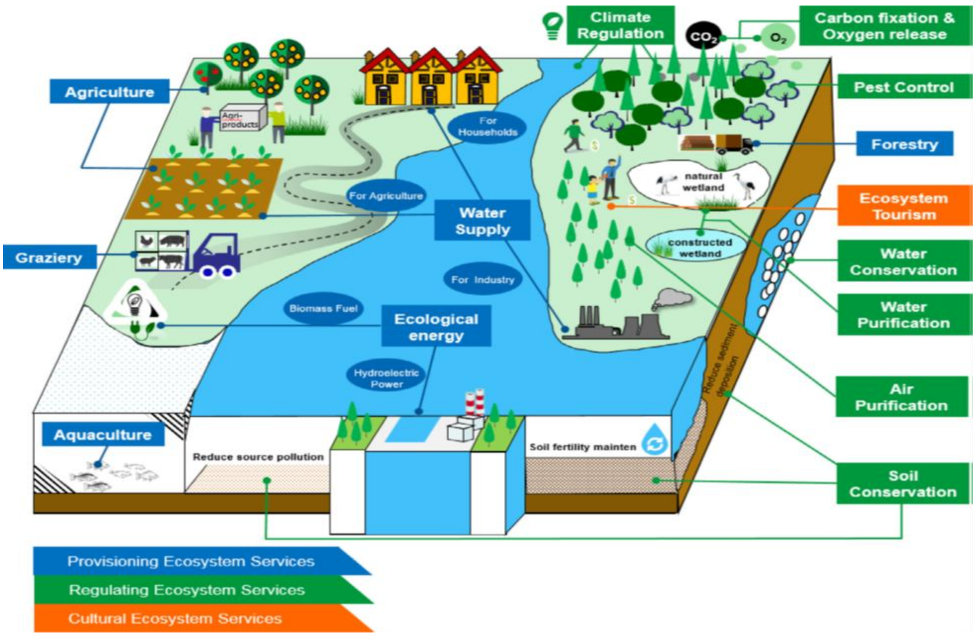
$$GEP = EPV + ERV + ECV + ESV$$

Ecosystem products include the following: natural food products, raw materials, energy, drinking water, natural chemicals and medicines, genetic resources, etc. Regulatory services include regulation of: climate, air quality, water quality, soil quality, erosion regulation, natural disaster regulation, pest regulation, oxygen production, pollination, noise suppression. The values of cultural services provided by the environment include: values of tourism and recreation, aesthetic services, educational services, spiritual values, values of establishing social relations, values of artistic inspiration. Ecosystem support services include habitat values, nutrient cycling, soil creation, water cycling, maintenance of genetic diversity, etc.

The GEP is based on a very ambitious and comprehensive procedure of non-market valuation techniques. Only a small number of GEP components can be monetarily valued through the market transactions. Therefore, one of the essential characteristics of the GEP is a broad use of non-market valuation techniques, primarily the use of so-called "benefit transfer method" (Pešić, 2020). At the same time, this is also one of the imperfections of the GEP concept (Chaozhi Hao et al., 2022). When it comes to practical applications of the GEP, most attempts have been made in China, owing to the possibility of large database uses, jointly with a political support of the Chinese authorities, both at the central and at the local levels. (Qingping Hu et al., 2023). The main justification can be found in a strong strategic commitment of the state to achieve sustainable development, along with the long-term preservation of natural resources (Haijiang Yang et al., 2023).

As an example, we should point out the recently published work of the Chinese economists (Liang et al., 2021) dedicated to measuring the ecosystem product in nine cities in the Pearl River Delta. The work is characterized by a precision and breadth of research into the value of ecosystem products, i.e. agricultural, forestry, livestock, fishing, products, water resources and renewable energy. The novelty is the evaluation of ecosystem regulatory services, such as water purification and conservation, soil conservation, air purification, carbon sequestration and oxygen emission, climate regulation, pollination, maintenance of biological balance in the relations of living species, etc. In addition, the analysis includes the evaluation of cultural services of the ecosystem, in terms of the aesthetic, inspirational, and educational functions provided by the environment.

Figure 1. Schematic diagram of Gross Ecosystem Product accounting in nine cities within the Pearl River Delta, China



Source: Liang et al., 2021

In spite the fact that works of Chinese scientists are pioneering, original, and interesting, a lot of skepticism still remains. Most critical considerations come from the Chinese scientists, too (Chaozhi Hao et al., 2022). Among the criticisms are: inconsistent understanding of ecosystem services, omission of essential services, overvaluation of cultural and supporting services, imprecise assessment of physical sizes and quantities, and high uncertainty in the application of non-market valuation techniques. Because of the above mentioned, problems with repeating of the previous results emerge, jointly with incomparability of the obtained results. Therefore, the basic prerequisites for validity of any scientific endeavor may be questioned. However, the mentioned criticism is rather a call for further improvements of the concept than its rejection. The fact that from 2021 the GEP is included in SEEA, as an important ecological-economic macro-indicator, speaks in favor of what has been said (United Nations et al., 2021).

Green Development Index

Comprehensive monetary valuation of the ecosystem services provides important information for policy makers, through monitoring of the Green Development Index (GDI). The GDI is defined as the ratio of incremental Gross Ecosystem Product and incremental Gross Domestic Product (GDI=ΔGEP/ΔGDP). The GDI index today represents the "golden standard" in all strategic decision-making processes related to the use of natural resources (Zhiyun Ouyang et al., 2020).

Nowadays a genuine profitability information of any project can be obtained by comparing a decrease in value of the Gross Ecosystem Product and an expected increase in value of the Gross Domestic Product. In all cases where the index is greater than one, there are firm reasons to reject any resource exploitation project, because the expected losses of the ecosystem value or the value of ecosystem "services" are greater than the potential increases in the Gross Domestic Product. In the opposite case, provided that GEP and GDP are calculated in accordance with the theory, there is a reason to accept the project based on the natural resource exploitation. However, even then, it should be taken into account that it is a static analysis, analysis at one point in time (when GEP and GDP changes are calculated). In a dynamic context, it is necessary to transform future cash flows into current values, which opens one of the most complex issues in the contemporary microeconomics, the issue of discounting (Golier, 2013). However, when it comes to the natural resource exploitation projects, the prevailing point today is that classic dynamic cost-benefit analyses can only be used conditionally, and with reservations, knowing that the ecosystem changes caused by the project may be mostly irreversible.

It is a pity that in Serbia there has not been a single attempt to monitor GEP and GDI indicators. The only successful attempt to economically assess the ecosystem service values in Serbia can be found in the doctoral dissertation of Zlata Markov, entitled *Pollinator insect fauna in Vojvodina: diversity, abundance and assessment of the economic value of pollination*, defended in the Department of Biology and Ecology of the Faculty of Sciences University of Novi Sad, in 2017.

Only through the analysis of ecosystem service values, strategic problems of economic development based on natural resources, would be solved in the right way. In this context, all infrastructure projects related to lithium exploitation in Serbia, should be scientifically analyzed. Unfortunately, by now, we have no information about any efforts of a kind.

Conclusion

Today the concept of Gross Ecosystem Product and the Green Development Index are attracting more and more attention around the globe. Chinese scientists have made and continue to make great efforts in the field. Despite criticism, this concept is subject to constant improvements, both at the level of specific regions, districts and cities, and at the national level. Further developments of GEP and GDI, particularly their use in strategic project evaluations and in making long-term development decisions are expected to be very useful. This opens up opportunities for upgrading the cost-benefit analysis, which represents a great advance not only in the economic theory but also in the policy of sustainable development. Unfortunately, in Serbia today, there are no attempts in this direction. Nothing of the global trends are followed nor the domestic efforts are made. This paper is intended to inform our professional public with the global trends in the area.

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Environmental Reporting in Serbia: The Case of Agribusiness Companies

Marina VASILIĆ[5]

Abstract

In this study we analyze environmental reporting practices on a sample of Serbian agribusiness companies, focusing on selected disclosures in their annual business reports. Agriculture is in spotlight as one of the biggest environmental contaminants. Such reputation highlights the importance of quality corporate environmental disclosures. Although formally regulated, environmental reporting in Serbia is to significant extent voluntary in nature. This produces serious informational risks for end-users and potentially enables the management to avoid penalties for environmental damage. Lacking intense regulatory and market pressures, analyzed companies appear not to be strongly committed to environmental reporting. We find that generally low quality of disclosures cannot be attributed to company-specific factors, but rather to the overall reporting environment. The results of our research may be useful for stakeholders, managers, regulators and researchers looking at the quality of environmental reporting.

Keywords: environmental reporting, agribusiness sector, sustainable reporting, environmental regulation

Introduction

On the verge of the fifth industrial revolution, the future of world-wide economies' sustainable development hinges on human-centric values, promoting dynamic implementation of environment and sustainability principles as an issue of paramount importance, both at state and company level (Kolaro et al., 2023). Being the most responsible for local and planetary problems, companies are urged to redefine success and incorporate sustainable development goals into their strategies, directing

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their activities towards long-term sustainable value creation and redesigning preferred performance metrics to include environmental and social results, in addition to the financial ones (Malinić and Vučković Milutinović, 2023). Commonly underlined as one of the key pollutants of the environment and main causers of climate changes the sector of agribusiness can be seen as especially vulnerable to such calls to action (Savić et al., 2020).

In these circumstances, traditional corporate reporting, focused on company's financial performance, inevitably becomes insufficient, failing to address the ever expanding informational needs of investors and other stakeholders (Škarić Jovanović, 2013). Fixating exclusively on economic growth, companies oftentimes fail to comprehend the bigger picture, neglecting the effects their operations have on the environment and wellbeing of coming generations (Spasić and Stojanović, 2013). Hence, in order to ensure future sustainable development, it is necessary for the companies to strengthen their environmental accountability, creating an extended reporting system that will allow the interested users to comprehend environmental risks and opportunities, and to assess their effects on company's performance.

There is a common belief that creating an environmentally friendly public image of the company has the power to promote its competitive advantage, reduce operational costs and mitigate litigation risks (Janjić and Jovanović, 2015). Therefore, it is no surprise that sustainable disclosures emerged as globally accepted, voluntary and/or mandatory reporting practice at the turn of XXI the century. However, the scope and quality of published information still significantly vary in practice, from "pale" to "deep" green, depending on the corporate environmental awareness and on the differences in national legal requirements and rules of financial reporting (Sekerez, 2016). Such settings inevitably cast a doubt on environmental disclosures' relevance and veracity, leaving the public to wonder is it just good marketing or, in fact, reality.

Hence, experts and academics advocate the regulation in the field, indicating that mandatory regime can improve the quality and comparability of environmental disclosures (Malinić and Vučković Milutinović, 2023, Sekerez, 2016). Still, there is a need for global harmonization, to reduce the informational risks stemming from differences in national regulatory requirements. Global Reporting Initiative (GRI) is widely recognized as an authority when it comes to sustainability reporting, and the recent engagement of the European Union and IFRS Foundation in the field promises significant progress in quality of environmental disclosures in the coming years.

Being an economy with an emerging capital market Serbia struggles with relatively weak market forces and poor regulatory infrastructure that hinder the quality of financial reporting (Vučković Milutinović, 2019). Reporting entities appear to focus solely on minimizing the costs of disclosures, not perceiving any additional reporting benefits other than legal compliance, altogether producing financial information of disputable quality (World Bank, 2015). Clearly, high-quality environmental reporting cannot be expected in such circumstances. Nevertheless, the importance of environmental issues urges the society to accept the fact that the environment is not a resource which can be exploited limitlessly and free of charge and that economic entities must be held accountable for their actions i.e. bear the consequences of environmental damage they produce.

Advocating the importance of environmental disclosures, we investigate the environmental reporting practices of Serbian agribusiness companies, seen as economic entities with one of the largest negative impacts on the environment. We use the Scoring and Serbian Business Registers Agency's databases to create a sample of companies and obtain necessary data. We then perform content analysis, focusing on compliance with local environmental disclosure requirements. Aiming to analyze the possible company-level determinants of environmental reporting quality, we further explore the effects of company's ownership structure, type of auditor, profitability and type of dominant creditor.

The paper is structured as follows. After the introduction, we summarize the regulatory framework for environmental reporting in Serbia. The next section presents the analysis of environmental reporting practices of Serbian agribusiness companies. The paper closes with a brief conclusion.

The regulatory framework for environmental reporting in Serbia

According to the prevailing legislation in the Republic of Serbia, environmental reporting is regulated by the Law on Accounting. Namely, companies are obliged to publish the information on the investment into protection of the environment as a part of their Annual Business Report (ABR). However, micro and small sized legal entities (except for public-interest entities) are exempt from this obligation (and from publishing any environmentally related information). Large-sized public-interest legal entities with more than 500 employees additionally compile a non-financial report (an integral part of their ABR) in which they are required to disclose the results of activities referring to the protection of the environment.

Except for these general requirements, universally applicable to all reporting entities regardless of the type of their predominant economic activity (and consequent environmental impact), there are no other additional guidelines on the preparation of environmentally related information, nor there are any reporting standards for recommended use. Hence, it can be argued that, although formally regulated and obligatory, environmental reporting in Serbia is to a significant extent voluntary in nature. Namely, the company's management has the right to decide on the content of environmental disclosures, their scope, length and mean of presentation. Consequently, environmental reporting can become a powerful medium in the hands of eco-conscious management, as well as an important part of a company's marketing strategy. Likewise, it can be reduced to a mere reporting headline, a single item to be crossed in the reporting checklist, deprived of any informational substance.

Such discretionary power unquestionably carries significant informational risks for the users of company's environmental disclosures. To make economically sound decisions, shareholders and stakeholders rely on fairly presented, relevant, reliable and transparent information, comparable in time and between entities. Independent auditor's report can provide some credibility, having in mind the legal requirement for the auditor to present a statement on the possible materially significant incorrect disclosures given in ABR and to elaborate on the nature of such disclosures. Additionally, the auditor is required to provide an opinion on the conformity of ABR with company's annual financial report, and its compliance to local regulations. Hence, it can be argued that management's discretionary power in environmental reporting can be reined in (at least to some extent) and directed to enhance the quality of disclosed information in practice.

Sample, data collection and research design

Our study is based on a sample of 97 Serbian agribusiness companies, mandatorily filing ABR for 2021 in accordance with local regulations that stipulate non-financial reporting on the investments in the protection of the environment. For the purpose of the analysis, *a company* is any business entity that is obliged to file its annual financial statements (and relevant accompanying reports) to the Serbian Business Registers Agency (including entrepreneurs, partnerships, llcs, jscs and cooperatives).

Having in mind the scope of their potential impact and the related significance of their environmental reporting, we have focused solely on agribusiness companies whose activities are deemed to be most threatening to the environment. In accordance to the prevailing regulation in Serbia[6], legal entities and entrepreneurs pay an annual fee for the protection and the improvement of the environment. The fee is determined in relation to the degree of negative impact of entity's operations (i.e. entity's predominant activity) on the environment (large, medium or small impact) and the size of the entity (as stipulated by the Law on Accounting). Economic activities with a large negative impact on the environment pertaining to agribusiness sector include the following activity codes:

01.46 Farming of swine
01.47 Farming of poultry
10.11 Processing and preserving of meat
10.12 Processing and preserving of poultry meat
10.13 Processing of meat and poultry meat products
10.20 Processing and preserving of fish, crustaceans and mollusks
10.31 Processing and preserving of potatoes
10.32 Manufacture of fruit and vegetable juice
10.39 Other processing and preserving of fruit and vegetables
10.41 Manufacture of oils and fats
10.42 Manufacture of margarine and similar edible fats
10.51 Operation of dairies and cheese making
10.52 Manufacture of ice cream.

Our initial sample comprises all companies with above-specified registered activity codes, according to the latest available data in the Scoring database in the moment of the analysis. Companies with zero revenues were eliminated from the sample, considering their lack of activity (and environmental impact) in respected year. The analysis was performed for the remaining 2,058 companies. Available ABRs for 2021, together with Notes to the financial statements and Independent Auditor's Report (where applicable), were hand-collected from the Serbian Business Registers Agency's public database of financial statements.

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[6] Regulation on the criteria for determining activities that affect the environment according to the degree of negative impact on the environment caused by the activity, amount of fees

Having in mind the overall impact of agribusiness sector on the environment, and the related significance of public disclosures regarding the investments agribusiness companies made, as well as the activities they performed in order to preserve the environment and promote sustainable development of the economy as a whole, we consider our research focus to be valid and our sample to be representative.

Table 1. The structure of analyzed sample of companies

Activity code	Total number of companies	Number of companies without revenue according to the latest available financial statement	Number of companies obliged to publish ABR for 2021	Number of companies with publicly available ABR for 2021	The share of companies with publicly available ABR for 2021 in the total number of companies	The share of companies with publicly available ABR for 2021 in the number of companies obliged to publish ABR for 2021
1	**2**	**3**	**4**	**5**	**6=5/2**	**7=5/4**
01.46	109	54	9	7	6.42%	77.78%
01.47	257	85	5	5	1.95%	100.00%
10.11	521	161	18	15	2.88%	83.33%
10.12	109	35	7	5	4.59%	71.43%
10.13	465	193	4	4	0.86%	100.00%
10.20	56	18	2	2	3.57%	100.00%
10.31	16	6	1	1	6.25%	100.00%
10.32	166	81	5	5	3.01%	100.00%
10.39	1,000	371	35	26	2.60%	74.29%
10.41	81	31	9	9	11.11%	100.00%
10.51	321	111	16	16	4.98%	100.00%
10.52	180	77	3	2	1.11%	66.67%
Total	**3,281**	**1,223**	**114**	**97**	**2.96%**	**85.09%**

Source: Author's calculation

We analyze the content of ABR for selected companies, disclosures made in their notes to the financial statements as well as potentially available additional reports, aiming not only to investigate their compliance with the prevailing disclosure requirements regarding the environmental reporting in Serbia, but also to gain insight into their reporting practices and comprehend possible underlying motives of their management. Making an effort to better understand possible determinants of environmental and sustainability disclosures, we further investigate the effects of company-related factors, including profitability, ownership structure, type of auditor and type of dominant creditor.

Results and discussion

The results of the analysis of environmental disclosures that could help the users to better understand the effects of company's operations on the pollution and preservation of the environment, the amount of company's investments into the protection of the environment, their nature and impact on company's performance and competitiveness on a sample of 97 Serbian agribusiness companies are provided in Table 2.

Table 2. The analysis of environmental disclosures in ABR

Description	Number of companies	Percentage
Company publishes Annual Business Report (ABR)	97	100.00%
Annual Business Report contains the section "*Information on the investment into environmental protection*"	85	87.63%
For the subsample:		
Company publishes the exact amount of investments into environmental protection (>=0)	31	36.47%
Company publishes that the amount of investments into environmental protection equals to zero	20	23.53%
Company publishes additional information on environmental protection	8	9.41%

Source: Author's calculation.

The overall impression is that the management of Serbian agribusiness companies does not seem to perceive the importance of environmental reporting or use the obligatory disclosures as a communication channel with external shareholders and stakeholders in general, let alone as a mean for improvement of company's public image. Namely, even the elementary requirement to publish the ABR is not met in 14.91% of the cases, while 12.37% of companies have failed to provide any information on the environmental issues in their ABR. Furthermore, only 36.47% of companies stated the actual amount of investment into environmental protection, but in the majority of cases (64.52%) that amount was equal to zero. Moreover, only 9.41% of companies published additional information on the effects their operations had in terms of environmental pollution, including the information on greenhouse gas emissions, carbon footprint, water pollution and treatment of waste. However, such information significantly varied both in content and presentation, making inter-company comparisons virtually impossible. Finally, not one company had published any environmentally related information in notes to their financial statements, and only one company voluntarily compiled a GRI report on sustainable development.

Especially worrying is the degree of diversity of environmental disclosures, in terms of content, length, presentation and language type. Disclosures vary from one sentence to two pages, containing information on actual actions taken during the year or general environmental policies and planned activities, including detailed amounts and types of investment or pure boilerplate text. At the same time, auditor's reports in all of the analyzed cases contain no special considerations regarding the environmental disclosures (even when they are missing), leading to a conclusion that such disclosures are generally considered as not materially significant.

Aiming to comprehend the effects of company-specific factors on management's tendency toward transparent environmental disclosures, we further investigate the potential effects of company's profitability, ownership structure, type of auditor and dominant creditor. Namely, it can be expected that companies with Big4 auditors and capital providers (owners and creditors) coming from other legislations with more stringent environmental regulations have better reporting practices, as well as profitable companies (as opposed to the ones operating at a loss). However, our findings generally speak in favor of relative insignificance of these characteristics, for the analyzed sample of companies.

Companies that invested in the protection of the environment and published the exact amount of these investments in their ABRs had a non-Big4 auditor in 81.82% of cases and a positive auditor's opinion in 72.73% of cases. The majority of these companies had a positive net result (90.91%), domestic natural persons as owners (72.73%) and various domestic creditors (90.91%). For the subsample of companies that published additional information on the pollution of the environment and taken actions, 62.50% had Big4 auditors, and all of them had a positive auditor's opinion on their financial statements for 2021 (ABR including). The majority of these companies had net profit (87.50%), foreign legal entities as owners (75%) and various domestic creditors (87.50%). Hence, it can be argued that widespread lack of quality of environmental disclosures can generally be more attributed to the overall reporting climate in Serbia rather than to specific, company-related factors.

Conclusion

Being among the most ecologically contaminated economies in Europe, Serbia craves for prompt action in the field – increased investments in environmental protection, improved regulations, more stringent monitoring. As economic entities and direct pollutants, companies are required to incorporate sustainable development goals into their strategies and to take responsibility for their environmentally damaging operations. Agribusiness sector seems especially important, having in mind the scope of its environmental impact. The need for strengthening company's environmental accountability creates an incentive to redesign the existing corporate reporting system, allowing the interested users to comprehend environmental risks and opportunities, and estimate their effects on company's performance.

Although formally regulated, environmental reporting in Serbia rests on significant discretionary rights of company's management in terms of content and presentation of necessary disclosures. Such circumstances create notable informational risks, potentially depriving the users of valuable decision-making information and enabling the management to avoid sanctions for created environmental damage. Analyzing environmental disclosures on a sample of 97 Serbian agribusiness companies, we have found the overall lack of quality, leading to the conclusion that their management does not seem to perceive the importance of such disclosures let alone use them as a communication channel with the general public. We believe that further regulation in the field is necessary and that additional reporting guidelines could prove especially valuable in terms of the overall improvement of quality and comparability of environmental reporting.

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Social Capital in the Function of Environmental Protection and Development of Rural and Urban Areas

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Abstract

The starting point of this work is the importance of social capital in the application of the concept of sustainability in urbanism and rural areas. Considering the three dimensions of sustainable development, social capital has a significant role in environmental protection and development of urban and rural areas. The positive effects of social capital are reflected in the preservation of biodiversity, resource management and the growth of social well-being.

Key words: Social capital, sustainable development, rural development, environmental protection, local self-government

Introduction

In order to be able to talk about social capital as a multidimensional and multifunctional process, which it certainly is, it is necessary to observe it through several parallel tracks, namely: (1) in relation to the principles of sustainability and rural development policy, (2) through the creation of a national politics, (3) development of local self-government, and (4) within the framework of environmental protection.

- The turn in the new thinking includes the entire rural area, and planning with a new methodology: from the bottom up. New concepts of rural development are expressed through concepts such as: sustainable existence of the rural population, social protection and new information technologies (Bogdanov, 2015).
- The concept of sustainable development includes three aspects: environmental, economic and social sustainability. Environmental

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sustainability concerns the protection of natural resources and the preservation of biodiversity; the economic concerns higher productivity and growth, and the social includes the development of institutions, participation in decision-making, social cohesion and a kind of identity.

- Social capital proves to be essential for explaining the success or failure of national policies and strategies, as well as the variations and dynamics of rural and social development in general. In this sense, a special measure was implemented within the support of rural development through LEADER[9] support.
- Local governments, for their part, form the institutional environment for local decision-making. These are all those policies that create synergy in the economic, social, cultural and environmental sense. In this way, multifunctionality is realized in the true sense of the word.
- The relationship between social capital and the state of the environment is shown in a double relationship: either the environment, including natural heritage, landscape, biodiversity is reduced to a material resource that should be used and exploited, or the value of preserving the environment and natural landscape is emphasized as the imperative of responsible social action and behavior.

The main goal of the paper is to show what social capital enables, that is, to point out all the transitivity and fluctuation of the concept of social capital, in order to connect it with different actions of individuals in preserving natural resources and mitigating climate change.

Conceptually, in the first part of the paper, different understandings and theoretical definitions of social capital are presented, as well as different measures of support at the regional and national level. The second part of the paper deals with the concept of sustainable development and the role of social capital in environmental protection, while the third part of the paper consists of concluding considerations on the importance and role of social capital in environmental protection, thereby enabling easier access, first of all, to natural resources, along with social and economic.

[9] The abbreviation LEADER stands for Liaison Entre Actions de Developpement de l'Economie Rurale

Theoretical definitions and understandings of social capital

In the 18th century, theorists started the study of the concept of social capital. Still interest for the concept does not cease. In relation to all the affirmation that this term receives in the modern socio-economic environment (globalization and the transition from the welfare state to the prevailing paradigm of neoliberalism), theoretical disagreements are still observed in an attempt to fully understand it. This should not be surprising if we know the nature of social capital, which is not static and constant, but a very variable and fluctuating social model.

Social capital is defined as bonds and relationships between individuals (Gray, Shaw & Farrington, 2006). It is a concept that includes the norms and values that guide people in communication and cooperation, is a measure of trust and participation in restrictions and institutions (political parties, unions, clubs, organizations), but also includes rules and relationships that facilitate the exchange of information, ideas and innovation.

Along with Rubio (1997) and Halpern (2005), Bourdieu (1999) believed that social capital is unevenly distributed, and as such helps maintain social inequalities and uneven distribution of power. Bourdieu distinguishes between economic, cultural and social capital. According to him, social capital includes resources that come from belonging to a group. For Bourdieu, the amount of social capital possessed by a participant depends on the extent of the network of connections that he can successfully mobilize, as well as on the capital at his disposal.

Coleman's concept (1988) of social capital includes exchange relations through kinship in family groups, through a network of friends and colleagues. Interpersonal relationships, contacts and connections indicate the existence of social capital. It is maintained and developed either through strong kinship ties or through weak, heterogeneous ties.

For Putnam (1993; 2000), the idea of social capital is inseparable from civic associations and organizations, whereby civic participation and engagement contribute to the efficiency of society through joint action. Social capital is seen as an attribute of the social structure in the horizontal plane through different societies, sports clubs, parties, cooperatives, choral societies, etc. The model advocated by Putnam indicates the positive effects that social control has.

With transformation processes, new socio-economic patterns and new forms of social organization are formed according to Held (1996). Instead of associations at the local level, television, social networks and the Internet create a new form of "virtual neighborhood", which changes the traditional forms of social organization through the transformation from local and regional to global networks.

Social capital is, above all, social potential, a link between different policies and concrete solutions to the challenges faced by urban and rural areas. Since social capital is determined by the people who form it in a certain territory, it is very important what their angle of observation is, i.e. how they see the social, economic and environmental conditions in their place. Possible scenarios range from weakening and difficulties in creating and maintaining different forms of social capital, through strengthening and facilitating its application and positive effects, but also moments when seemingly marginalized and devastated areas maintain functional social capital, regardless of economic and social deterioration.

In an institutional sense, different national policies should promote trust between local actors, such as the LEADER initiative. The LEADER program enables the realization of economic advantages and the strengthening of social capital, with the support and initiation of local development. It is implemented with the funds of the EU, national governments and the funds of the private sector.

But social capital can also have negative consequences for those individuals who do not want to adopt local norms, which entails social exclusion, isolation, crime and social deviations.

The concept of sustainable development

Climate changes, irrational use of resources and global devastation of the environment have contributed to the actualization of the concept of sustainable development. In literature exist different definitions of sustainability. According to the definition of the Final Report of the Brundtland Commission, sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (World Commission on Environment and Development [WCED], 1987, cited in Jovanović-Gavrilović, 2008). Pešić (2020) defines sustainability as an essential prerequisite, but also as the ultimate goal of the efficient organization of numerous human activities on Earth. Derlukiewicz et al., (2020) see sustainable development as a strategic trend that unites socio-economic development and global environmental protection. According to (Emas, 2015), the general goal of sustainable development is the achievement of eco-ecological stability, which is achievable through the integration and appreciation of economic, social and ecological aspects in the decision-making process.

Bearing in mind, sustainable development is becoming the dominant development paradigm of various economies in the world. Sustainable development is a multidimensional concept that includes three different segments: (1) economic, (2) social and (3) environmental. In other words, progress in one dimension depends on achievement in the other two (Stevens, 2011). For example, economic productivity will be impaired if there is an imbalance in the social and environmental segments.

Effective implementation of this concept implies defining and achieving various goals of sustainable development. Currently, there are 17 goals that essentially represent the concretization of the mentioned dimensions. Each of the goals should have the following specificities: (1) be precisely defined, (2) measurable, (3) achievable, (4) realistic, (5) and time-limited (Jovanović-Gavrilović, 2008). Achieving the goals implies the coordination of various activities of the participants (inhabitants, companies, organizations), and the necessary institutional support.

In this regard, there are two groups of indicators for monitoring the performance of the implementation of goals (Jovanović-Gavrilović, 2006):

1. The PSR (Pressure-State-Response) model, which includes a set of indicators for monitoring the impact on and state of the environment, as well as adequate responses to the achieved effects. There is also a variation of the mentioned model in the form of DSR (Driving force-State-Response) which incorporates socio-economic indicators. For example, based on the DSR model, we can measure the impact of human activities and social processes on the improvement of the ecological picture and economic growth.
2. A system of national accounts that includes individual and aggregate indicators, which are most often expressed in monetary or physical units. For example, some of the indicators show the amount of investment in the environment, or the state of a certain natural resource.

In general, the long-term concept of sustainable development implies constant economic growth that ensures poverty reduction, better management of resources, improvement of health conditions and quality of life, reduction of pollution and preservation of biodiversity. Sustainability is based on education, R&D, digital society and low-carbon economy, contributes to higher employment on the one hand, and a more equal social position of different groups on the other.

The role of social capital in environmental protection

The specifics of social capital can also be viewed through the lens of environmental protection. Namely, different connections between individuals can contribute to the preservation of natural resources, a higher rate of recycling, mitigating climate change, reducing the carbon footprint, which ultimately improves environmental performance. In other words, the development of the social segment of sustainability can encourage the achievement of the goals of the ecological dimension.

We can analyze the influence of social capital on the improvement of the ecological image through various forms of association of individuals and market participants. To begin with, we highlight the role of environmental movements and organizations. In general, environmental movements can be defined as networks of informal interactions between individuals, groups and/or organizations, which are engaged in joint action and goals inspired by environmental care (Grasso & Giugni, 2015). Kousis & Uba (2021) list three basic types of environmental movements: (1) formal environmental organizations, (2) diverse social groups, and (3) radical environmental groups.

According to (Grasso & Giugni, 2015), ecological movements have the following specificities: they are heterogeneous in nature, they easy change and transform form, and often become institutionalized. Heterogeneity is often reflected in the inclusion of different participants, the definition of goals, the choice of strategies, as well as in the context of the effects of the movement itself. In general, environmental organizations can play two roles. In this regard, they can be aimed at more efficient management of natural resources (water, forests, national parks) or aim at raising environmental awareness through permanent education of society. Within the first mentioned role, Pretty & Ward (2001) make a distinction between groups that are focused on a certain resource, e.g. water protection, forest management, soil irrigation, etc. A common characteristic of all environmental organizations is the easy diffusion of information, knowledge and ideas between members, which leads to the creation of a stimulating environment for achieving environmental, economic and social sustainability goals. The synergistic action of one or more ecological groups contributes to the balance between the three segments of sustainable development. The presence of social networks have expanded environmental organizations activities. For example, in Serbia, organizations for the preservation of the rivers of Stara Planina or for the prohibition of lithium mining have used the potential of social networks in order to spread environmental activism.

On the other hand, environmental organizations can have also an educational role. The diffusion of circular economy ideas, renewable energy sources and global warming principals, aim to inform the general public and draw attention to the importance of environmental issues. It also close together diametrically different economic and environmental goals. For example, Eco Hub10 and Eco Serbia11 organize creative eco-workshops in elementary schools in Belgrade.

Consequently, environmental activism can encourage companies as main subjects of economic activity to produce green products, which can increase the profitability and market share of companies, but also greater exports of the economy (Hysa et al., 2020). A positive "domino effect" not only reduces negative externalities, but also leads to wider economic effects. In addition, the social association of individuals can encourage the horizontal and vertical linking of enterprises into clusters. Clusters represent a type of locational association of companies that contributes to the growth of productivity, innovation and competitiveness of the economy (Porter, 2008).

Non-Governmental Organizations (NGOs) represent local support for environmental organizations, and another form of social capital in environmental protection. NGOs not only prevent further devastation of nature and renewable and non-renewable resources, but indirectly promote conditions for education, gender equality and poverty reduction as important determinants of global sustainability (Bouzarjomehri & Javani, 2020). In other words, NGOs with their activities and support alleviate various limiting factors, while at the same time stimulate the productivity of the social, economic and environmental context.

The emergence of green consumers groups on the market has stimulated the development of the green operations in companies. The growth in the

[10] Source: https://www.ecohub.rs/ [accessed: 12.4.2023].
[11] Source: www.ecoserbia.blogspot.com [accessed: 12.4.2023].

number of customers who prefer green products increases the demand and has a positive impact on the improvement of the green production innovative potential (Lin, Tan, & Gang, 2013). For example, consumer initiatives can encourage companies to recycle more or use recyclable raw materials, thereby creating green products with a higher degree of added value for environmentally conscious customers. In addition, it lowers costs of purchasing inputs, packaging, collecting and disposing of waste, and it will have a positive impact on the business result. Also, it will reduce the pressure on limited resources, as well as the impact on the environment. The new paradigm of business has defined new forms of communication with customers (via social networks), as well as new ways of declaring and labeling products. According to Agyeman (2014), the following product characteristics: price, quality, packaging, brand and environmental impact, are important to green consumers.

Conclusion

The paper presents the multifunctionality of the concept of social capital in achieving social well-being, environmental protection and consequent economic development. In this regard, in the first step, we defined the concept of social capital, as well as the various specificities and characteristics of it, which contribute to a greater degree of sustainability. Horizontal or vertical connections between individuals encourage the strengthening of social potential resulting in a proactive approach for solving the various challenges in rural and urban areas. The strength of the above-mentioned connections, but also the presence of external (exogenous) factors influence that we always view social capital as a fluctuating and non-constant social model.

In the second step of the paper, we have presented the importance of sustainable development as a dominant development paradigm in the global framework. Sustainability as a concept of development, becomes extremely important both at the individual (micro) level and at the national and international level. Effective implementation of sustainability implies a balance between the social, economic and environmental segments. Accordingly, the paper analyzes the role and cohesiveness of social capital, as a component of the social dimension, in environmental protection and economic development of rural and urban areas.

Actualization of environmental issues has contributed to the development of new forms of social capital: environmental movements and organizations, groups of green consumers, and non-governmental organizations. All the mentioned forms of social association encourage more efficient use of resources, reduction of waste and pollution, climate change management, use of renewable energy sources and improvement of the ecological image. In addition to the direct impact on the environment, social capital indirectly affects the increase in the efficiency of the company's performance, as the main subjects of economic activity. For example, the emergence of green consumer groups will encourage the innovative capacity of companies in the context of green product development, and will cause the reduction of certain operating costs.

The development of social capital leads to the growth of micro-competitiveness. Also, the appearance of green products can contribute to the growth of urban and rural population employment and the growth of exports as important indicators of economic development. In other words, the role of social capital is very important for the implementation of green and sustainable principles, as well as for economic growth and competitiveness of the entire economy.

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Land Degradation in the Republic of Serbia and Human Well-Being According to the UNCCD Methodology[12]

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Abstract

This paper presents an assessment of land degradation in the Republic of Serbia according to the United Nations Convention to Combat Desertification (UNCCD) methodology and indicators of population well-being related to degradation processes. The methodology monitors trends in land cover, land productivity and soil organic carbon stocks. The result of the changes in the indicators is the proportion of degraded land. The data on the indicators were adopted from global databases. Compared with reference period, the proportion of degraded land is 4.2% of the country's area, around 367,100 ha, which represents an increase. Among the indicators, the largest negative changes concern land productivity, with 211,200 ha. The results have lower confidence level, but after ground-thruting and the improvement of input data quality, the application of methodology could be relevant for national level decision-making. The link between the socio-economic indicators and the land degradation assessment is rated with low confidence.

Key words: land degradation, Republic of Serbia, UNCCD, population well-being

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Introduction

Life on planet Earth increasingly depends on sustainable land use. One of the fundamental functions of soil is to provide food for humans and animals. Yet land is being degraded and its productivity is declining. Land degradation can be characterized as one of the basic problems of the modern times, as it poses a serious threat to human well-being (Životić and Vuković Vimić, 2022). These threats are related to the existing processes of land degradation, population growth and rising expectations in living standards on the one hand, and the increasing scarcity of natural resources on the other. Soil degradation refers to the transfer of mass and energy, which can be negatively characterized from the point of view of soil functions. These processes are accelerated by anthropogenic activities and the increasingly frequent occurrence of extreme weather conditions and climate change. Degradation processes are easily observed in vulnerable climates and poor societies, but they also affect developed economies. Land degradation certainly has the greatest impact on the lives of people engaged in agriculture. Although much has been said and written about this topic worldwide, the available literature and statistics on affected areas and their negative impact on productivity can be very confusing (Lal, 2018). The economic cost of land degradation globally is estimated at USD 490 billion per year (UNCCD, 2016), while the annual cost of land degradation in Serbia is estimated at USD 254 million (Global Mechanism of the UNCCD, 2018).

This paper aims to present the results of the assessment of land degradation in the Republic of Serbia using the methodology adopted for reporting to the United Nations Convention to Combat Desertification (UNCCD) and to present the indicators of population well-being that the Convention uses for reporting.

The UNCCD is the only international legally binding agreement that links environment, development and sustainable land management. With the concept of land degradation neutrality (UNCCD, 2016), the UNCCD strives to achieve a balance between sustainable land use, habitat restoration and rehabilitation, and land degradation processes (Životić et al., 2017). This concept is part of the Sustainable Development Agenda. The UNCCD Secretariat is the custodian agency for indicator 15.3.1: "Proportion of degraded land over total land area", and covers reporting on this topic. The monitoring of this indicator aims at maintaining or improving the land-based natural capital compared to the reference state. The Convention also adopted a strategic framework for the period 2018–2030 with five strategic objectives and a framework for their implementation. Strategic objective 1 relates to improving the condition of affected ecosystems, combating desertification/land degradation, promoting sustainable land management and contributing to land degradation neutrality. Other strategic objectives relate to improving the living conditions of the affected populations, combating drought, generating global benefits for the environment, and mobilizing funds to support the implementation of the UNCCD. The indicators for monitoring Strategic objective 1 are trends in land cover, land productivity, and carbon stocks above and below the ground, and the proportion of land that is degraded over total land area. Changes in the indicators are determined by comparing global or national datasets on the indicators over defined periods of time. Data from global databases were used for the assessment of land degradation in the Republic of Serbia,.

The European Space Agency - Climate Change Initiative (ESA CCI-LC), a dataset with 36 land cover classes with a spatial resolution of 300 m, was used to produce data on land cover changes. The UNCCD land cover legend includes seven simplified land cover classes for the purpose of analysis: tree-covered areas, grasslands, cropland, wetland, artificial areas, other land and water bodies. Therefore, changes in land cover are characterized as positive or negative according to the generated conversion matrix that is defined at the beginning of the analysis. For example, conversion of tree-covered to arable land, or conversion of arable land to urban areas, are characterized as negative, and indicate land degradation. The analysis tracks changes in land cover in the reference period 2000–2015 and changes in the period 2016–2019 compared with the reference period. In the process of data verification, some negatively defined changes can be characterized as positive and vice versa – false positive and false negative. The verification process is also used for the assessment of other indicators.

The European Commission’s Joint Research Center’s land productivity dynamics data set (LPD) with a spatial resolution of 1 km, created by processing time series of SPOT VGT NDVI satellite images at 10-days intervals, was used to elaborate land productivity dynamics data. This method of assessing land productivity was also used in the World Atlas of Desertification to monitor land degradation at a global scale (Cherlet et al. 2018). Land productivity is defined as the biologically productive capacity of land, which is the main source of food and raw materials needed for human survival (Sims et al., 2021). Land productivity metrics are determined after elaborating data on productivity trend, state and performance. A productivity trend shows the trajectory of productivity change over a long period of time. The productivity state represents the degree of productivity change in relation to multi-year observations in the same area. Productivity performance indicates local productivity changes compared to similar areas in the region. The elaboration of the three productivity metrics leads to six classes of permanent land productivity trajectories: declining, early signs of decline, stable but stressed, stable (not stressed), increasing, and no data. According to the methodology, the LPD changes are monitored for the reference period and the changes in 2016–2019 are compared with the LPD results of the last 16 years.

The ISRIC (International Soil Reference and Information Center) dataset, SoilGrids, with a spatial resolution of 250 m, was used to obtain data about trends in soil organic carbon (SOC) stocks. SOC stocks are expressed in t/ha, and refer to a depth of 30 cm. Estimates of SOC changes are provided in Good Practice Guidance for the determination of indicator 15.3.1 (Sims et al., 2021). The assessment method uses information on land cover change, along with SOC stock change factors, i.e. factors of land use, land management and organic matter inputs factors. The status of change in the SOC stock is considered to be degradation if there is an average net decrease of 10% compared with the reference period. The analysis monitors changes for the period 2016–2019 compared with the reference period.

Layering of the results of the three indicators mentioned above is used to determine the proportion of the degraded land over the total land area. The results of the analysis are integrated according to the "One out-all out" principle, which means that if a negative change in one of the indicators occurs on an area, this area is considered degraded, even if the other two indicators are unchanged or improved (Sims et al. , 2021). This principle is used in data processing with the possibility of including the false positive and false negative connotations already mentioned in the analysis.

To assess the improvement of living conditions of the population affected by land degradation, the UNCCD uses three indicators: trends in the proportion of the population living below the international poverty line or trends in income inequality, trends in access to safe drinking water, and trends in the population exposure to land degradation disaggregated by sex. Income inequality in the Republic of Serbia is determined by the GINI index, which indicates the extent to which the distribution of income among individuals or households within an economy deviates from perfectly equal distribution (https://databank.worldbank.org/metadataglossary/world-development-indicators /series/SI.POV.GUINI). Data on the GINI index, drinking water supply and spatial distribution of the population can be found in the databases of the Statistical Office of the Republic of Serbia (SORS) (www.stat.gov.rs).

Results and Discussion

Land cover changes in the period 2016–2019 compared with the reference period are characterized as land degradation on 0.5% of the area of the Republic of Serbia, at around 43,100 ha. Changes in land cover at the end of the reference period compared to its beginning amount to 89,500 ha. This means that the changes in land use, referred to as land degradation, have decreased in absolute terms, but when these changes are expressed on an annual basis, the changes in the period 2016–2019 are more intense. This negative connotation of land use refers primarily to the loss of arable land through conversion to urban areas.

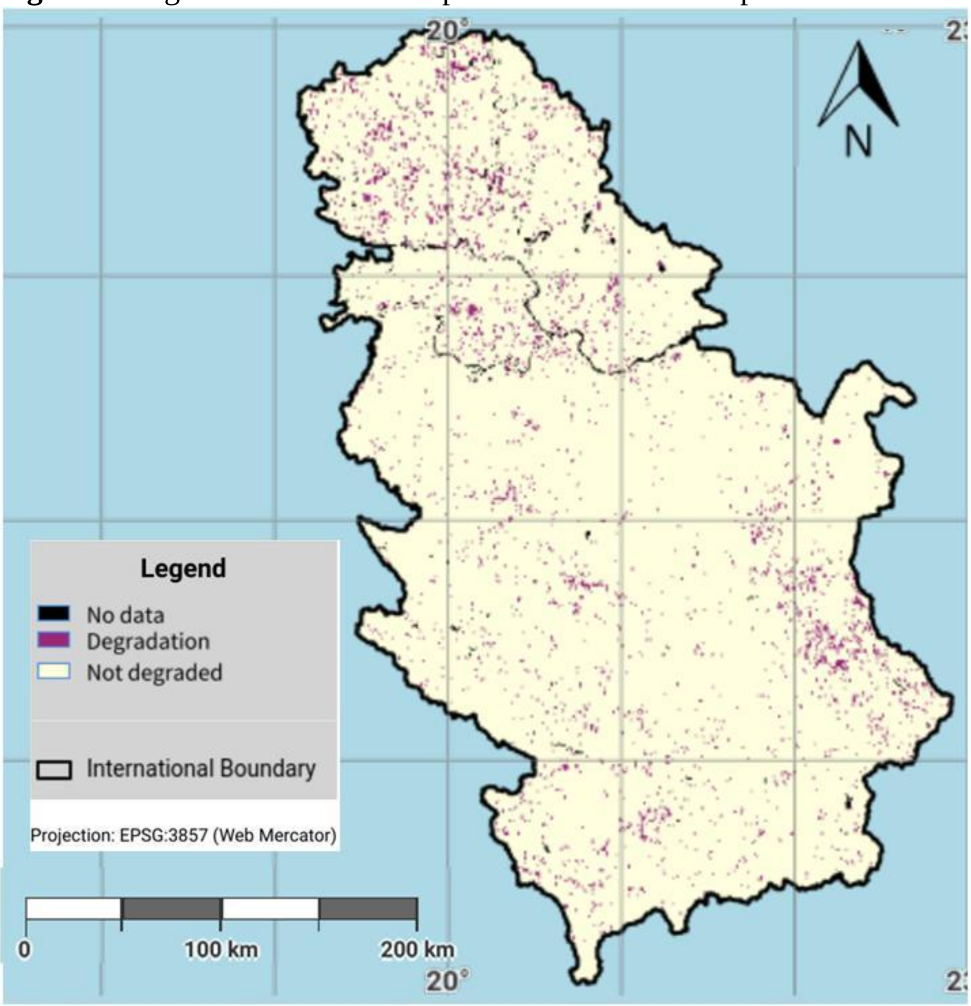
Negative changes in land productivity were observed on 78,200 ha, or on 0.9% of the area, during the reference period, while they were identified on 2.4% of the area, i.e 211,200 ha during the study period. The area with stable land productivity covers 65.7% of the country, while the area with improved productivity covers 31.9% of the country. The greatest decline in productivity occurs after the convertion of arable land and forests to artificial land.

Negative changes in SOC stocks were determined in 0.7% of the area, i.e. 57,900 ha, for the reference period. Land degradation due to reduction of SOC for the period 2016–2019 was identified at 66,000 ha, i.e. 0.8% of the country's area. During the studied period, SOC stocks decreased from 107.5 to 105.0 t/ha after the conversion of forests to arable land.

The total area of degraded land according to the UNCCD methodology in the reference period is 165,900 ha, which is 1.9% of the country's land area, whereas in the 2016–2019, the degraded area is 367,100 ha, which is 4.2% of the country's territory (Figure 1). Apart from the aforementioned human impacts, this increase can also be linked to the occurrence of an intense drought in 2017, which affected land productivity.

The results obtained are assessed with low confidence and were calculated without taking into account false positives and negatives in the analysis. In order to increase the level of confidence of the obtained results, it is possible to use the Corine land cover database for Serbia when processing the land cover data, and convert the Corine classes into the seven classes proposed by the UNCCD according to the IPCC guidelines. In order to improve the land productivity results, it is necessary to use a higher resolution of global data, e.g. Trends.Earth Land Productivity, which uses a spatial resolution of 250 m, as well as to verify the obtained results in the field. For this reason, the confidence level of these data is described as low, or rather unknown.

Figure 1. Degraded areas in the Republic of Serbia for the period 2016-2019



Source: PRAIS4 platform (https://www.unccd.int/our-work-impact/country-profiles/serbia)

The confidence level of the global SOC data is also characterized as low. In the Republic of Serbia, there is a large amount of data on the SOC stocks. However, these data have rarely been collected from SOC campaigns and have not been systematized, i.e. they need to be verified before official use, and have therefore not been used in this analysis.

The results of the investigation of population well-being indicate that poverty decreased according to the GINI index, as the values dropped from 39.8 in 2016 to 33.3 in 2020. Unlike in arid regions, the increasing trend in degraded land in Serbia does not correlate with the trend in the GINI index. The lack of input data prevents the determination of the GINI index at the pixel level and the spatial overlap with degraded areas to establish more accurate correlations between degradation and income. According to SORS data, the proportion of the population using drinking water that is part of the collective water supply network increased from 85.9% in 2016 to 89.9% in 2020, which represents progress. Global data on the proportion of Serbia's population exposed to land degradation indicate a decrease in the affected population from 10.9 to 10.3% in the two observed periods, with a 0.2% higher share of the female population in both observed periods. A spatial analysis of the affected population and degradation processes is disabled due to the lack of official population data at the pixel level. The UNCCD methodology attempts to show the relationship between socio-economic indicators and land degradation, but currently the lack of input data of adequate quality, resolution, and data format, hinders both the qualitative and quantitative determination of this dependency. For this reason, it can be said that the results obtained are also very unreliable from this point of view. An accurate analysis of the impact of land degradation on the well-being of the population can only be conducted after ground-truthing of land degradation data, and by analysing the identified hotspots in more detail.

The UNCCD methodology applied is used for global purposes. In the Republic of Serbia, there is no prescribed methodology for land degradation assessment and the results obtained, although of low confidence, are nevertheless used for reporting to the global community. Under the conditions of countries where the process of desertification has been observed for a long time, this methodology has proven to be reliable, but under other climatic conditions it may lead to wrong conclusions. In particular, under our conditions, linear forms of erosion, which constitute a significant part of the degradation processes in our country, are insufficiently identified and the effects of climate change are not taken into account. The socio-economic aspect of land degradation and the relationship between land degradation and climate change are also not yet sufficiently addressed both at the international level and in our country.

Conclusion

Land degradation is a serious threat to the well-being of mankind, especially under climate change conditions. Using the UNCCD methodology, it was determined that the total area of degraded land in our country is 4.2% of the country's land area, or 367,100 ha. These results were obtained without a more in-depth qualitative analysis of the degraded areas, which aimed to assess the direct and indirect drivers of land degradation, determine the types of land degradation and the status and intensity of the degradation processes. The use of higher resolution input data can improve the estimates and guide further work on the problem of land degradation. The relationship between indicators of well-being and land degradation is also considered to be of low confidence, although progress is being observed in the indicators measured. The UNCCD methodology, although global, can serve as one of the bases for monitoring degradation problems at the regional level, after the verification of the results, and thus contributing to ecosystem restoration and improving the lives of the population.

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Contribution of Small Hydropower Plants to Energy Production from Renewable Sources

Simo STEVANOVIĆ[18], Radovan ŽIVKOVIĆ[19]

Abstract

Rapid economic development and exponential population growth have led to increased energy consumption and pollution.

The programme for the construction of small hydropower plants (SHPs) in Serbia, which is based on the Cadastre for the construction of SHPs from 1987, provides for the production of an additional 1590 GWh of electricity from RES. As it turned out during exploitation, the water potential was overestimated and the impact of the SHPs on the water balance and the environment was neglected.

The possibility for SHPs owners to acquire the status of a privileged producer of electricity and thus use incentive measures for delivered kilowatts of green energy has influenced the intensive construction of SHPs over the last ten years.

The aim of the paper is to point out the advantages and disadvantages of the construction and exploitation of SHPs, as well as to point out the experiences of other countries in the production of energy from this source.

Keywords: renewable energy sources (RES), small hydropower plants (SHPs), environment, environmental pollution.

Introduction

The exponential population growth that has occurred from the 18th century until today, accompanied by scientific and technological advancements, has directly contributed to increased consumption of natural resources, resulting in the disruption of the natural balance. We are witnessing climate change as a consequence of increased greenhouse gas

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emissions, and with growing concern, we are trying to find ways to produce energy in a sustainable and environmentally friendly manner. In this context, energy production from renewable sources, including small hydropower plants (SHPs), has become an essential factor in the energy balance of every country.

The significance of small hydropower plants (SHPs) in providing clean energy lies in the fact that hydro energy is a renewable energy source that is abundant on Earth. As a result of solar energy and the natural circulation of water in the environment through natural watercourses such as streams and rivers, there is a tremendous potential for producing clean and renewable energy. Hydropower plants enable the conversion of this potential into useful forms of energy, thereby reducing greenhouse gas emissions and humanity's dependence on fossil fuels for energy production.

In addition to the aforementioned benefits, small hydropower plants (SHPs) have numerous other advantages due to their smaller size compared to larger hydroelectric plants. The installation of SHPs rarely requires the construction of large dams and reservoirs[20], minimizing habitat loss and the impact on local ecosystems. SHPs contribute to local energy security and reduce transmission losses over longer distances. There are also other advantages and disadvantages that will be discussed in more detail in the subsequent chapters of this study.

The aim of this study is to assess the benefits, advantages, and disadvantages of constructing and utilizing small hydropower plants (SHPs) for electricity production from renewable sources, as well as to examine the experiences of other countries in energy production from this source. Based on the positive and negative experiences of other countries in SHP electricity production, it is possible to propose solutions that will minimize environmental harm in the areas where they are constructed for Serbia.

In researching the production of energy from renewable sources, the advantages and disadvantages of energy production from small hydropower plants (SHPs), as well as the consequences for the natural environment in which they are constructed, relevant scientific and expert literature pertaining to the researched issues has been utilized.

[20] Derivational small hydropower plants

State of SHPs worldwide and in Serbia

In the EU, there are approximately 23,000 hydropower plants, out of which around 21,000 are small hydropower plants (91%), but they only account for 13% of the total electricity generated from hydropower (EU Commission, 2015). In Germany, there are 7,300 small hydropower plants, but they contribute only 0.06% to the annual electricity production (Eichelmann, Scharl, 2017). Moreover, these plants often cause severe ecological damage, including the endangerment or complete destruction of wildlife. Similar situations can be observed in Austria, where 2,202 small hydropower plants produce only 4% of the electricity from hydropower, while 417 larger hydropower plants contribute to 96% of the electricity production (Eichelmann, Scharl, 2017). Between 1993 and 2017, due to their low energy contribution and significant ecological consequences, authorities in the United States removed more than 1,000 diversion-type small hydropower plants. Similar processes are taking place in France, Spain, Germany, and Sweden, where the alteration of smaller watercourses has significantly reduced the populations of certain fish species and other organisms. As a result, the quality of over 70% of the habitats in watercourses with small hydropower plants in the EU has been assessed as "poor, unsatisfactory, or bad" (EEA, 2015). In accordance with the criteria of the EU Water Framework Directive, approximately 47% of European watercourses do not have a "good ecological status" (EEA, 2012).

Serious discussions on the appropriateness of small hydropower plants, especially in mountainous regions, are taking place in the European Parliament due to their pronounced negative ecological effects, particularly in the Alpine regions of Austria, Germany, France, and Italy (EP Forum RFAE, 2015). In France, between 1998 and 2005, the government decided to demolish four dams on the Loire River to restore the population of salmon that migrates to the Atlantic Ocean (Marks, 2007). The Chinese provinces of Sichuan and Yunnan have restricted the construction of small and medium hydropower plants until 2020 due to unacceptable negative impacts (https://www.hydroreview.com). In India, due to the inability to obtain environmental permits, they have abandoned 36 small hydropower projects with a capacity of 26,000 MW (https://www.business-standard.com). Ontario province in Canada has canceled 758 contracts for feed-in tariffs for renewable energy production (https://globalnews.ca). The main criticisms are related to ecosystem degradation, loss of biodiversity, fragmentation of fish habitats, and increased erosion. The European Commission has instructed Romania to assess the sustainability of the small hydropower plant concept, as they have built over 500 facilities in a very short period, significantly impacting the quality of aquatic ecosystems in the mountainous Carpathian regions. As a measure to reduce the number of small hydropower plants, the EU proposes the abolition of feed-in tariffs applied to renewable energy production.

According to a study (RiverWatch, CEE, 2018) conducted by European organizations dedicated to the protection of watercourses, between 2013 and 2015, eight small hydropower plants were built in Albania, Croatia, and Macedonia, with funding from the European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB). This has resulted in the disappearance or reduction of populations of endemic and protected fish species, jeopardized water supply for local communities, and intense erosion on access roads. International financial institutions have identified significant instances of non-compliance with national legislation and environmental protection standards, leading to a reassessment of the business policies related to the financing of small hydropower plant construction.

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Serbia is among the few countries in the world that had a small hydropower plant in operation as early as the beginning of the 20th century. In 1900, the first hydroelectric power plant, "Pod gradom," was built on the Đetinja River in Užice. Subsequently, in 1903, the "Vučje" plant was constructed on the Vučjanka River in Leskovac, followed by the "Gamzigrad" plant on the Crni Timok River in Zaječar in 1908, and the "Sveta Petka" plant on the Nišava River near Ostrovica in 1911. The

"Moravica" plant was also built on the Moravica River in Ivanjica. This marked the beginning of electrification in Serbia, with the introduction of public lighting and the operation of the first industrial machines powered by electricity. By 1990, a total of 17 small hydropower plants with capacities up to 10 MW were constructed, meeting current environmental protection criteria regarding the utilization of available hydro potential and environmental impact. From 1954 to 1990, the construction of hydroelectric power plants intensified in Serbia, including the development of major energy systems on the Vlasina, Uvac, Lim, Drina rivers, as well as the "Djerdap I and II" hydroelectric power plants on the Danube River. Since then, no new hydroelectric power plants have been built in Serbia. Depending on hydrological conditions and production plans, the share of hydroelectric power reaches up to 30% of the total electricity production, making it the most significant renewable energy source in Serbia (Dimitrijević, 2020).

The Energy Act[21] of 2004 established incentives for the use of renewable energy sources (RES) and environmental improvement. The amendments to the Energy Act[22] in 2011 allowed companies and entrepreneurs to engage in electricity production based on licenses and registration in the appropriate register of electricity producers. Energy facilities can be constructed in accordance with the Planning and Construction Act and relevant technical regulations.

The Strategy for the Development of Serbia's Energy Sector[23] defines priorities and incentive measures for electricity production from renewable sources. It is estimated that the technically exploitable potential amounts to 19,500 GWh per year, of which only 1,800 GWh (9.2%) is attributed to small hydropower plants (up to 10 MW). The strategy also highlights limitations on the construction and use of hydropower plants in rivers located within protected[24] areas, which will be implemented in accordance with environmental protection criteria.

In June 2013, the National Action Plan for Renewable Energy (NAPOIE, 2013) was adopted, which envisaged the construction of

[21] Službeni glasnik RS“, br. 84/2004
[22] Službeni glasnik RS, br. 57/2011 i 87/2011.
[23] Službeni glasnik RS, br. 101/2015.
[24] Parkovi prirode, kulturno - istorijske i ambijentalne celine i izvorišta za vodosnabdevanje.

hydroelectric power plants with a total capacity of 458 MW by 2020 and a total of 750 MW by 2030. Of this capacity, small hydropower plants (MHE) were expected to account for approximately 50%, or 208 MW by 2020, and 400 MW by 2030.

The previous experiences of small hydropower exploitation

In 2013, the Ministry of Energy of Serbia, based on the Energy Law and the National Action Plan for Renewable Energy Sources (NAPOIE), as well as the Small Hydropower Plant Cadastre in Serbia, which was created in 1987 and identified 856 locations for small hydropower plant construction south of the Sava and Danube rivers, and 13 locations in the Autonomous Province of Vojvodina, issued a public call for granting approvals and energy permits for small hydropower plant construction in Serbia. However, after the initial results of small hydropower plant construction, it was determined that due to non-compliance or deficiencies in project documentation, these plants were causing significant damage to the environment at the site of diversion and watercourse utilization. To address these identified issues, the Ministry of Energy adopted a Regulation that established a list of projects requiring mandatory environmental impact assessment (EIA) and a list of projects for which an EIA may be required, including small hydropower plant projects. The Regulation stipulates that an Environmental Impact Assessment Study is only required for small hydropower plants with an installed capacity exceeding 2 MW. Therefore, for small hydropower plants with a capacity below 2 MW, an Environmental Impact Assessment Study is not mandatory. Furthermore, the Regulation on Protection Regimes[25] allows for the construction of small hydropower plants with a capacity of up to 5 MW in protected areas under the second level of protection (Ristić et al., 2020).

However, our regulations do not specify a standardized methodology for determining the minimum sustainable flow. Instead, various approaches exist for determining the ecological flow. These approaches involve analyzing the hydrological and hydraulic characteristics of the river flow to ensure the survival and development of the plant and animal life within the influence zone of the SHP on the water regime.

Determining the minimum sustainable flow for small hydropower plants (SHPs) is conditioned by the prescribed content of the technical

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[25] Službeni glasnik RS, br. 31, 2012.

documentation submitted when obtaining water and location conditions. An obligatory part of the technical documentation is the hydrological study and calculation of characteristic water flows at the water intake location. The minimum sustainable flow is limited to at least 10% of the mean annual water flow. When intensive SHP construction began, significant changes in river flow conditions were observed, leading to the application of the Guaranteed Ecological Flow (GEF) method. It is determined for two periods of the year: 10-15% of the mean annual average for the cold part of the year (October - March) and 15-25% of the mean annual average for the warm part of the year (April - September). In order to ensure a secure flow continuity, in exceptional cases, for small watercourses, the minimum sustainable flow can reach up to 40% of the mean annual average.

A simpler method for determining the ecological flow involves capturing up to 95% of the characteristic flow values in relation to the mean annual water flow or the monthly low flow. Hydraulic methods are more complex as they take into account a greater number of other characteristics of the river flow. These methods generally prescribe a minimum water depth in the section where flow reduction occurs, ranging from 10 to 30 cm, and minimum water velocities of 0.3 to 0.5 m/s, aiming to facilitate the movement of aquatic organisms, maintain continuous flow, and prevent water stagnation (Dimitrijević, 2020).

The extent of damage that occurs during the operation of a hydropower plant depends on the method and accuracy with which the ecological flow is determined, as well as how well the hydropower plant operator adheres to the specified maximum water intake.

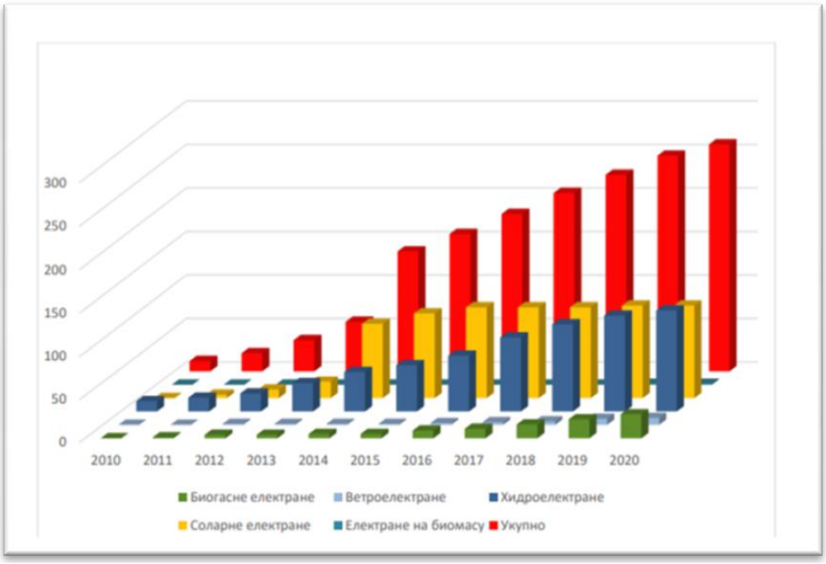
Incentives for produced 'Green energy'

Since 2009, when the legal framework for incentive measures (feed-in tariffs) was established, a total of 222 facilities with an installed capacity of 111 MW have been built for the production of electricity from renewable energy sources in Serbia (NAPKOIE, 2018). Considering only small hydropower plants with a capacity of up to 10 MW[26] that have obtained the status of privileged producers, the installed capacity in Serbia amounts to 62.9 MW, which is only 33.5% of the planned capacity for 2020. When it

[26] By the end of 2018, none of the planned hydroelectric power plants with a capacity of over 10 MW, out of the planned 250 MW of production, had been constructed.

comes to wind energy, much better results have been achieved in the construction of wind parks. However, there is an upper limit that the Serbian power system can accept from wind energy. Namely, the moment a wind park stops operating due to lack of wind, the power system needs to compensate for the loss of production with another energy source. For such situations, reversible hydropower plants are ideal as a complement to wind farms. During periods of high electricity production from wind farms, the reversible power plant stores water in the reservoir, while during periods of low or zero production from wind farms, the reversible power plant generates an increased amount of electricity and does not store water in the reservoir. Serbia has a much larger capacity for electricity production from wind farms, but further development is limited by the construction of new reversible power plants.

Graph 1. Number of all types of renewable energy power plants since the introduction of feed-in tariffs.



Source: NPOIE, p. 8.

In order to implement the Energy Development Strategy, regulatory changes have been made and incentive measures have been introduced, enabling profitable investments in the construction of small hydropower plants (SHPs). SHP owners are allowed to obtain the status of privileged producers, which guarantees them the opportunity to sell the generated energy at a privileged price of 7.8-13.7 c€/kWh during a 12-year incentive period.

By 2013, 31 small hydropower plants (SHPs) had been constructed and put into operation, and three SHPs owned by JP EPS (Ovčar Banja, Međuvršje, and Radaljska Banja) underwent revitalization of facilities and equipment to gain privileged producer status. As of 2018, a total of 102 SHPs had been constructed and commissioned, with an annual production reaching 266 GWh of electrical energy. As of April 2019, 104 SHPs had obtained privileged producer status, and an additional 21 SHPs had temporary privileged producer status due to their ongoing construction. Considering their projected capacities, it can be expected that by 2020, the total installed capacity of SHPs would reach approximately 91 MW, with an annual production of around 370 GWh, which corresponds to 45% of the action plan for this period when considering the revitalized SHPs managed by JP EPS (Dimitrijević, 2020).

Conclusion

The production of energy from hydropower plants contributes to the achievement of the set goals for the share of renewable energy in the total final energy production. Considering the contribution of hydropower plants to the overall energy balance of the country, experiences from previous construction and operation of hydropower plants worldwide vary. Research has shown that the share of energy produced from hydropower plants is low (up to 5%), while the environmental damages incurred during their construction and operation are disproportionate to their contribution to the electricity production balance. The construction of diversion hydropower plants often has permanent negative consequences on water regimes and the ecosystem of river systems, and it is frequently in conflict with the concept of water management and regulation. Environmental damages in Serbia occur through the construction of hydropower plants in natural reserve zones, protected areas of national parks, nature parks, and water supply sources.

Diverse interpretations and incorrect calculations and determinations of the ecological guaranteed flow downstream of water intakes lead to the permanent destruction of watercourses as valuable hydrographic and ecological systems of the country. In practice, it has been confirmed that investors do not comply with or avoid prescribed conditions regarding the ecological flow, causing unacceptable destruction of water and coastal ecosystems and biodiversity impoverishment over a wider area.

The incentives (feed-in tariffs) received for the production and delivery of each kilowatt-hour of green energy serve as a strong motivation for investors to build hydropower plants. In order to prevent environmental damages and guided by the energy, economic, developmental, and sociological benefits of hydropower plants, some countries have discontinued regulations promoting the production of energy from renewable sources.

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Organic Agriculture in the Function of Sustainable Development of Agriculture of the Republic of Serbia[27]

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Abstract

This paper analyzes the level of development of organic crop and livestock production in Serbia for the period 2010–2021 in order to determine the trends of changes in the observed period. The classification and clustering of the districts of Serbia were made on the basis of the data on organic crop production. Organic livestock production was not considered in the analysis, as it is very low or non-existent in most districts. Five homogeneous groups of districts were filtered out by cluster analysis, each cluster having peculiarities in terms of the expression of some of the observed indicators. Ranking of districts of Serbia based on the percentage of organically cultivated land was carried out using I-distance. Organic production in Serbia is becoming more popular and economically significant, but still at an unsatisfactory level. Considering the available natural resources, knowledge and global demand for organic products, it should be developed and promoted in Serbia in an organized way.

Key words: sustainable development, organic agricultural production, districts, Republic of Serbia

Introduction

The relationship between man and nature dates back to the earliest civilizations and evolved in parallel with the development of society to reach unimagined proportions and very great importance today. It was this

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relationship that was mostly negative and questioned the survival of the planet. Due to the increasing pollution of nature, greater exploitation of limited natural resources, global warming and climate change, economic inequality in the world, population growth, and economic crisis, the concept of sustainable development becomes essential for survival. Over time, sustainable development has become the key to achieving a balance between the conservation of the planet's natural potential and resources and their use. Sustainable development is a balanced development between economic growth, social progress and environmental protection that allows the needs of current generations to be met without compromising the ability of future generations to meet their own needs (Sarić, 2016).

Sustainable agriculture is a production method that, when considered over time, improves the quality of the environment and the resources on which production is based, meets human food needs, is economically profitable, and improves the quality of life of farmers and society as a whole (Bogdanov, 2015). The previous practice of giving priority to the economic aspects of agricultural production over others has led to the fact that most foodstuffs used for human and animal consumption now contain substances that are harmful to health. The excessive, uncontrolled, and often unprofessional use of fertilizers and plant protection products with the aim of achieving higher yields and profits is the cause of the decline in soil quality and fertility and the neglect of food quality and safety for human and animal health (Popović and Paunović, 2008).

Modern organic agriculture is based on ecological principles, which means at the same time economic production and preservation of agricultural and ecological systems. It implies the production of high quality food, safe for health, controlled and certified, meeting the needs of the modern consumer and contributing to the rational use of resources and the protection of the environment. Today, organic agriculture is developing rapidly around the world as a response to the obviously damaged environment and, above all, as a response to consumer needs for high quality and safe food. For this very reason, organic production is a controlled production method from the field to the table, which is a preventive measure against possible damage to the ecosystem, but also to human health (Lazić and Babović, 2008).

The territory of the Republic of Serbia is characterized by favorable conditions for the development of organic agricultural production. Traditional attachment of the population to agriculture, small farms, favorable agro-ecological conditions, ban on cultivation of genetically modified organisms, established institutions in the field of organic agricultural production and access to large markets are very good conditions for the development of organic agriculture in Serbia (Popović, 2016).

Therefore, the first objective of the study is to identify the trends in the surface structure of organically farmed land and the number of animals in organic livestock production in the Republic of Serbia over the last 12 years. Then, first of all, the districts of the Republic of Serbia would be grouped according to the size of cultivated areas for organic crop production based on eight indicators, and their ranking would be performed in order to see the level of representation of areas under organic plants.

Method of work

In order to achieve the research objective, the database of the Ministry of Agriculture, Forestry and Water Management for the period from 2010 to 2021 was used, which covers areas under organic plant production (cereals, fodder crops, industrial crops, vegetables, medicinal and aromatic plants, meadows/pastures, fruit and others), as well as the number of livestock (cattle, sheep, goats, horses, pigs, fish and bee colonies) involved in organic livestock production. Based on the above-mentioned indicators, time series analysis is performed and the tendency of change of organic production resources in Serbia will be defined by calculating the trend equation, as well as the growth rate coefficients. The assessment of the representativeness of trend equations is defined by the coefficient of variation ($C_{\hat{y}_i}$) (Maletić, 2005).

In order to form homogeneous groups of the districts by representing areas with organic plant production, a proximity matrix was defined on the basis of the data matrix using the Euclidean distance:

$$d_{rs} = \sqrt{\sum_{j=1}^{p} \left(x_{rj} - x_{sj}\right)^2}$$

The grouping of the units was done using the Ward's method, which is based on the sum of the squares between the groups (Maletić, 2000):

$$D\left(E_i, E_j\right) = \frac{n_i . n_j}{n_i + n_j} \sum_{k=1}^{p} \left(\bar{x}_{ik} - \bar{x}_{jk}\right)^2$$

Ranking of districts of Serbia based on the percentage/representation of areas under plant organic production was carried out using I-distance (Ivanović, 1963):

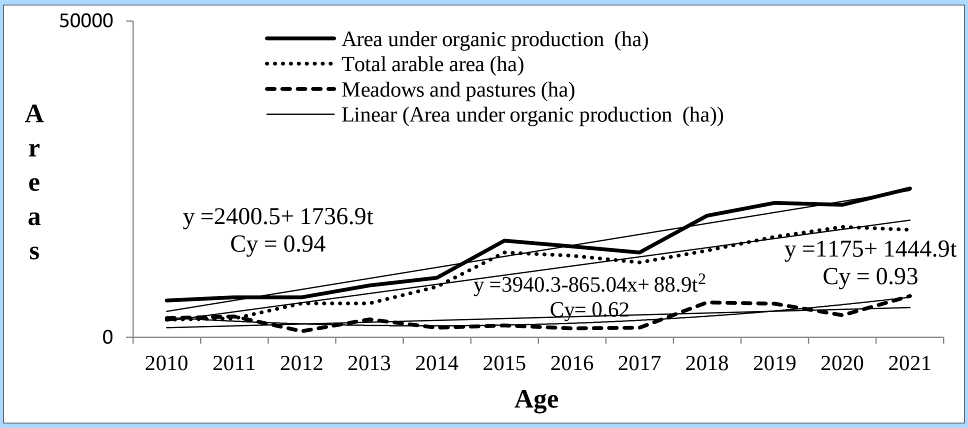
$$D_k = \sum_{i=1}^{n} \frac{|x_{ik} - x_i^-|}{\sigma_i} \prod_{j=1}^{i-1} (1 - r_{ij})$$

Data were processed using the *Microsoft Excel* program and the *SPSS* software package.

Research results

Analyzing the period from 2010 to the present, a growing trend in the total area of organic agriculture can be observed (Graph 1).

Graph 1. Areas under organic production (2010–2021), ha



Source: MAFWM

The largest increase was recorded in 2015 (15,298 ha, including 13,398 ha of arable area and 1,900 ha of meadows and pastures). In that year, the total arable area increased by 67.50% compared to 2014, while meadows and pastures increased by 22.66%. A significant increase in area was also recorded in 2018. Particularly noteworthy was the increase in the area of meadows and pastures (5,531 ha), which is two and a half times larger than in 2017. This has certainly had a positive impact on the development of livestock production. The largest total area for organic production was recorded in 2021 (23,527 ha, of which 17,003 ha of total arable area and 6,524 ha of meadows and pastures).

The trend of changes in areas for total organic production and total arable areas is best described by linear trend equations, and the quadratic trend model describes areas for meadows and pastures. These functions with a high degree of fulfillment are fitted to the original data. The average relative annual change in organic production in a 12-year period, i.e., the average dynamic coefficient, was 1.135% (total organic arable area), 1.179% (total arable area), and 1.071% (meadow and pasture), and the average growth rate was 13.5%, 17.9%, and 7.1%, respectively.

During the observed period, the number of producers involved in organic production has steadily increased. Most producers are involved in group certification as subcontractors (about 90%). This model has proven successful in our country and in most cases it is production intended for export. The first significant increase in the number of producers was recorded in 2012, when the growth rate compared to the previous year was 232.20%. After that year, the trend of growth per year was much lower (from 15 to 50%), and in 2017, there was a jump in the number of producers compared to the previous year (104.69%) with a trend of further growth. The following year (2018), the number of producers of organic products was the highest (6,706), after which the number decreased slightly. Today, there are about 6,500 producers of organic products. The average annual rate of change in the total number of producers is about 42%.

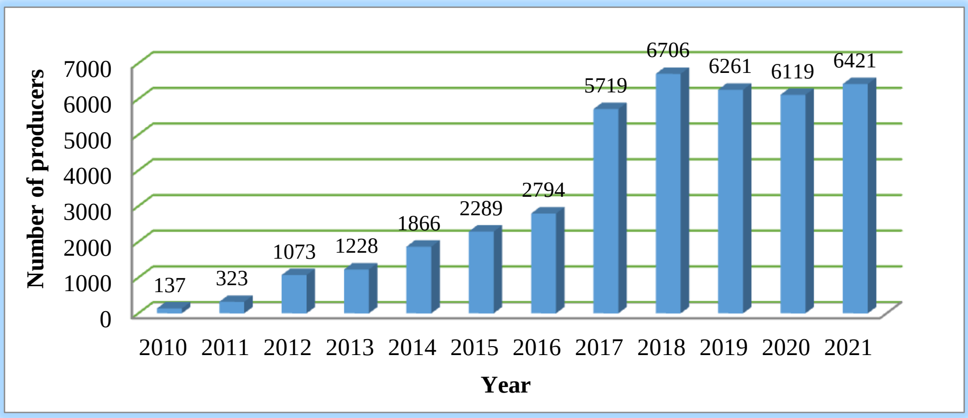
Table 1. Growth rate of different categories of organically farmed land (%)

Year	Area under organic production	Total arable area	Meadows and pastures	Producers involved in organic production
2011	8.20	8.01	8:34	135.76
2012	0.08	78.38	-70.66	232.20
2013	29.78	-0.17	194.36	14.44
2014	14.61	49.37	-46.08	51.95
2015	62.23	67.50	22.66	22.67
2016	-6.14	-3.50	-24.79	22.06
2017	-6.51	- 8.15	8.33	104.69
2018	43.44	15.56	257.30	17.26
2019	10.44	15.97	-3.27	-6.64
2020	-1.39	9.66	-34.26	-2.27
2021	12.19	-2.60	85.50	4.94

Source: Authors' calculation based on MAFWM data

Organic livestock production is much more demanding than crop production, both in terms of primary production and marketing of organic livestock products. In order for a farm to practice organic livestock production, the facilities for livestock production, the procurement of the animals, and the nutrition and treatment of the animals must meet special conditions and satisfy additional requirements. In addition, in order to place these products on the market, the technological conditions required by law for processing, storage and transportation must be met in accordance with the regulations for organic production. All this requires significantly more financial resources than the production and marketing of organic plant products. Therefore, fewer producers are engaged in organic livestock production in Serbia than in organic crop production.

Graph 2. Number of producers involved in organic production (2010-2021)

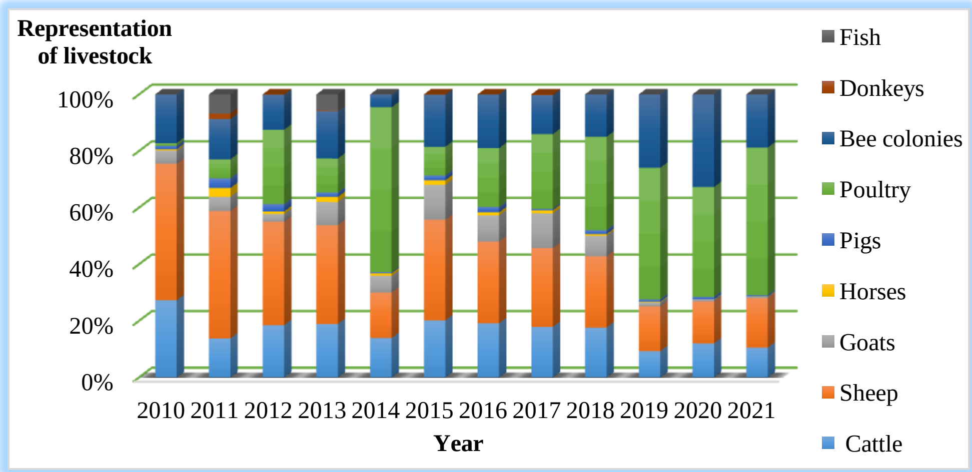


Source: MAFWM

At the beginning of the observed period, sheep, cattle and bee colonies accounted for the largest number of animals in organic production. These animals continued to play an important role in organic livestock production. For example, the number of cattle increased by 25% in 2021 compared to 2010, sheep by 24%, and bee colonies by 37%. With the increase in the number of farms producing organic livestock, poultry farming occupies an increasingly larger share. The increase in the studied period amounted to 96% compared to 2010. The number of pigs kept fluctuated slightly during the observed period, mostly around 300 animals, but today it is 24% higher than in 2010. The number of goats increased until 2017 and then decreased rapidly. Thus, the average growth rate during this period was only 12%, while that of horses was 14%. In the period from 2011 to 2014, there were farms that included the rearing of donkeys and carps in organic livestock production, but they quickly abandoned the idea because they could not determine any financial effect.

In order to determine how the districts in the Republic of Serbia are grouped according to the level of development of organic production, a cluster analysis was carried out, the task of which is to group the districts into specific groups (clusters) so that the elements within the cluster have a high degree of “natural association” with each other and at the same time the clusters themselves are “relatively distant” from each other. Organic livestock production is excluded from the database because it is represented only for certain types of animals and in certain years. Because data are very modest, grouping was based only on eight indicators that monitor the areas under organic plant production: cereals, fodder crops, industrial crops, vegetables, medicinal and aromatic plants, herbs, meadows - pastures, fruits and others.

Graph 3. Organic livestock production in Serbia

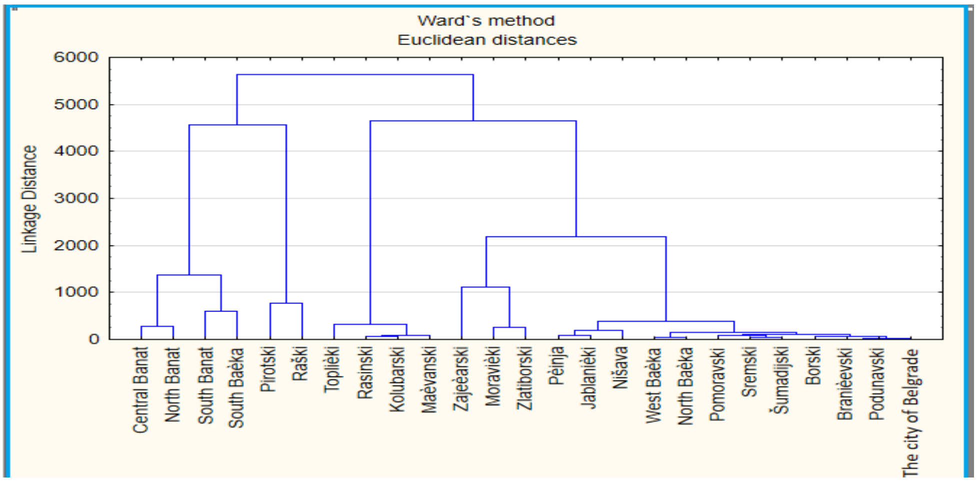


Source: MAFWM

The obtained hierarchical structure of the district is graphically represented in a dendrogram and then in a cartogram, from which the classes of districts forming certain homogeneous units are clearly visible. There are 5 clusters with different numbers of districts. The first and third clusters include four districts each, while the second cluster has only two districts and the fourth cluster has three districts. The remaining twelve districts belong to the fifth cluster.

The first cluster includes four districts of Vojvodina (Central Banat, North Banat, South Banat and South Bačka) with the largest areas under organic plant production. Most cereals, industrial crops, vegetables and forage crops are grown in these areas. Due to the large areas under forage crops, livestock production has also developed here, mainly cattle and poultry. The production of organic fruits and medicinal and aromatic plants is present, but not to the same extent as in some other districts. The second cluster includes the districts (Pirot and Raška) with the largest areas of meadows and pastures, but also with significant areas for forage crops and cereals. Therefore, sheep and cattle breeding is extremely developed in these districts. The third separate cluster (Toplica, Rasina, Kolubara and Mačva) is characterized by the cultivated areas and the production of organic fruits, while the production of industrial plants and medicinal and aromatic plants is almost absent.

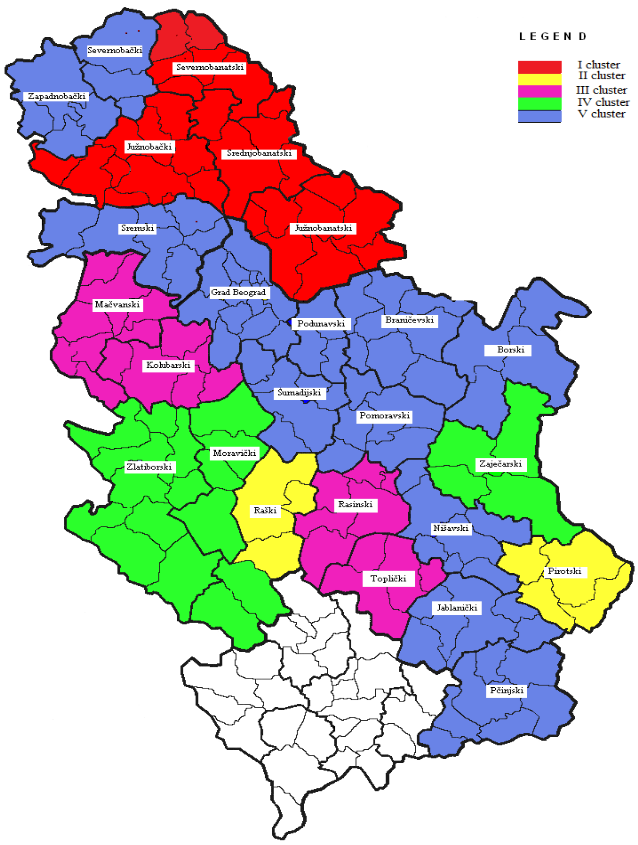
Graph 4. Dendrogram of isolated clusters of districts of the Republic of Serbia based on the representation of areas under organic plant production



Zaječar, Morava and Zlatibor districts form the fourth homogeneous unit, which is characterized by slightly lower cultivated areas for cereals, fruits, meadows and pastures compared to the other groups. Zaječar district has the largest cultivated areas under medicinal and aromatic plants. The remaining 12 districts form the fifth cluster and most of them belong to the region of South and East Serbia (6 districts) as well as three districts from Vojvodina, two districts from Šumadija and the city of Belgrade. The main characteristic of these districts are small areas of cultivation of organic crops. Areas under cereals, industrial crops, vegetables, forage crops, aromatic and medicinal plants are little or not represented (with the exception of the district of Pomoravlje). Only the districts of Nišava, Jablanica and Pčinja have somewhat larger areas under organic fruit cultivation. It can be said that the last cluster consists of districts with the least represented areas under organic plant production.

Taking into account the total areas of organic plant production by districts, the ranking of districts in Serbia was carried out based on the eight, previously mentioned indicators of plant production using the I-distance (Ivanović, 1963) (Table 2). The areas under cereals contributed most to the ranking of districts, followed by forage crops, etc. Organic fruit area had the least influence on the ranking. The defined ranking of districts confirmed the clustering results.

Graph 5. Distribution of districts of the R. of Serbia according to separate clusters based on the representation of areas under organic plant production



The districts of the first cluster are at the top of the ranking list because they have the largest areas under almost all organic crop production, while the districts of the fifth cluster, which have the smallest areas under organic crop production, are at the bottom of the formed list. It can be seen that Pirot and Zaječar districts are at the top, although the first belongs to the second cluster and the second to the fourth cluster. The reason for this is clear. Pirot district (the third on the list) has the largest areas under meadows and pastures and almost the largest areas under medicinal and aromatic plants. Zaječar district occupies a high fifth place, as it has the largest areas under industrial crops as well as under aromatic and spice plants, and the areas under fruit are also significant. All other districts coincide with the selected clusters and confirm their characteristics.

Table 2. Ranking based on indicators of crop production of districts in the Rapublic of Serbia

Ranking based on crop production indicators			Significance of the indicator	
District	I-Distance	Rank	indicator	Correlation
South Bačka	26.88	1	Cereals	0.80
North Banat	22.99	2	Forage crops	0.69
Pirot	16.86	3	Other	0.67
South Banat	15.92	4	Industrial plants	0.55
Zaječar	14.25	5	Vegetables	0.53
Toplica	9.62	6	Medicinal and aromatic plants	0.46
Central Banat	9.44	7	Meadows/pastures	0.28
Kolubara	7.72	8	Fruits	0.09
Rasina	6.34	9		
Mačva	5.89	10		
West Bačka	5.58	11		
Morava	5.58	12		
Raška	5.48	13		
Pomoravlje	2.21	14		
Nišava	1.73	15		
Zlatibor	0.96	16		
Pčinja	0.92	17		
North Bačka	0.77	18		
City of Belgrade	0.53	19		
Jablanica	0.30	20		
Srem	0.05	21		
Šumadija	0.04	22		
Bor	0.02	23		
Braničevo	0.01	24		
Podunavlje	0.00	25		

Source: Authors' calculation based on MAFWM data

Table 2 shows the importance of the indicators used, i.e. how much they contributed to the formation of the final ranking.

Conclusion

The prospects for the development of organic agriculture in Serbia are exceptionally good due to the very favorable natural conditions and unpolluted environment, as well as the employment of a large number of unemployed people, since it is a labor-intensive production. The consumption of organically produced food in developed countries is increasing, while the supply cannot meet the growing demand. Consequently, the opportunity opens up for countries with a lower level of development, where optimal ecological conditions prevail in rural areas, to increase the production of organic food and then bring it to the international market, where they can make a profit many times higher compared to the export of conventionally produced food (Popović, 2016). Organic production contributes to the sustainable development of agriculture from an ecological and social point of view. It is based on ecological principles and the preservation of the environment, which contributes to the sustainable development of agriculture from an ecological point of view. The social importance of organic production is reflected in the higher employment of the working-age population, especially in rural areas, as it is a labor-intensive production, thus reducing poverty and keeping young people in the countryside. The economic importance is reflected in the reduction of unemployment, the economic strengthening of family farms and the economic development of rural areas. However, despite these benefits and the prospects for the development of organic production in Serbia, the results achieved in the last 12 years are more than modest. By 2017, the National Strategy for the Development of Organic Agriculture in Serbia expected an area of about 50,000 ha. The largest total area under organic production was recorded for 2021 (2,527 ha), which is not even half of the expected area and represents only about 0.61% of the total agricultural land in Serbia.

During the observed period, the average area growth was recorded, i.e., the average relative annual change in areas under organic production, i.e., an average dynamic coefficient of 1.135% (total area under organic production), 1.179% (total arable area) and 1.071% (meadows and pastures). Organic livestock production is extremely low. The most widespread are sheep, cattle and bee colonies. The number of these animals has increased in the last 12 years, so that the number of cattle has increased by 25%, sheep by 24% and bee colonies by 37%. The number of producers involved in organic production has steadily increased over the observed period. A small number of producers have a direct contract with authorized control organizations, while the majority of them participate as subcontractors in group certification.

Organic production in the districts of Serbia was analyzed by cluster analysis and the existence of five homogeneous groups of districts according to the area under organic crops was determined.The districts were ranked according to the same criterion by applying the I-distance, and the results of this analysis confirmed the results of the cluster analysis. Organic agriculture has not been yet sufficiently accepted in Serbia and is at a low level. The reasons for this situation are mainly very low environmental awareness of consumers, as well as insufficient state support for this sector of agriculture, but also a decrease in the standard of living of the population and a decrease in purchasing power. Government incentives have decreased over the observed period, so that in 2022 incentives for organic crop production amounted to RSD 28,000/ha (https://serbiaorganica.info/podžajna-sredstva/aktuelni-podsticaji/). In 2011, they amounted to RSD 36,000/ha for field crops (cereals, industrial crops, medicinal and aromatic plants), RSD 50,400/ha for organic vegetable production, and RSD 64,800/ha for fruit and viticulture production (http://otvorenavlada.rs/uredba-organska-provodnja0466-lat-doc/).

Incentives for organic livestock production in 2022 amounted to: 21,000 dinars/head of cattle for fattening, 2,800 dinars/head of small livestock, for beehives 1,120 dinars/hive, etc., https://preduzetnistvo.gov.rs/programi/poljoprivreda/podsticaji-za-organsku-stocarsku-proizvodnju-2/?_rstr_nocache=pismo753637b4cc32cd33 and are also reduced compared to 2011. At that time, incentives to support the development of organic production were 21,600 dinars/head of large livestock, 7,200 dinars/head of small livestock, 2,800 dinars per hive, etc. (http://otvorenavlada.rs/uredba-organska-proizvodnja0466-lat-doc/.). With the strategy and necessary measures to affirm and promote organic production, state institutions should contribute to the massive development of this sector, based on raw materials, comparative advantages, identified market opportunities, and food industry opportunities with a focus on healthy organic food production programs for which there is a demand in domestic and foreign markets.

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Organic Production and Agenda 4.0

Tatjana BRANKOV[30], Miladin ŠEVARLIĆ[31]

Abstract

This paper deals with the concept of Agriculture 4.0, which represents the transformation of traditional agriculture through the application of advanced information and communication technologies (ICT). Special attention is given to the potential application of the latest technological advancements in the organic farming system. In the given example of the company "Login Eko," the concrete implementation of these technologies in organic production is demonstrated. It is concluded that the integration of new technologies contributes to resource preservation, carbon emission reduction, and increased productivity.

Key words: Agriculture 4.0, Information and Communication Technologies, Organic production

Introduction

Industry 4.0 in the field of agriculture, known as Agriculture 4.0, represents the fusion of the latest technological advancements that significantly increase production while simultaneously saving water, energy, fertilizers, pesticides, and other resources. This revolutionary approach to food production relies on the application of modern information and communication technologies (ICT) and contributes to increased production productivity, adaptation to climate change, more efficient resource allocation, sustainable waste management, and improved food quality (Zhai i sar., 2020).

The application of modern technologies in agriculture, such as the Internet of Things (IoT), robotics including drones, and artificial

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intelligence, has been the subject of numerous studies in recent years. Elijah et al. (2018) identified specific advantages and challenges of IoT. The use of IoT can help promote agricultural communities, especially in rural areas, through shared data storage, information exchange, and enhanced interaction between farmers and agricultural services. It also plays a significant role in ensuring safety and preventing fraud, increasing competitive advantage, wealth creation, and its fair distribution, reducing costs and waste, improving operational efficiency, and generating enhanced business models. The main obstacles to wider adoption of this technology include farmers' lack of knowledge, potential privacy concerns, device costs, data storage, processing, and transmission expenses. Saiz-Rubio & Rovira-Más (2020) analysis confirms that adequate knowledge leads to informed decision-making at the farm level and that the management system can process data in a way that enables customized solutions for each individual farm.

Braun et al. (2018) point out that seemingly simple technologies such as Bluetooth, GPS, or RFID enable the creation of a self-optimizing structure in the agricultural supply chain. Belaud et al. (2019) have designed an approach that integrates Industry 4.0 into the supply chain to enhance sustainability in managing agricultural waste valorization. In their work, Ayaz et al. (2019) highlight the benefits of using sensors in soil preparation, irrigation, disease, and pest detection, as well as unmanned aerial vehicles for crop monitoring and yield optimization. The use of unmanned aerial vehicles in real agricultural environments is also discussed in other studies, which describe multi-robot systems that overcome the challenges and limitations of simpler robotic systems currently used in smart farming (Kim et al., 2019). Miranda et al. (2019) apply the concept of "sensing, smart and sustainable (S3)" to develop new technologies that effectively address current challenges in the agri-food industry. Ferrag et al. (2020) analyze privacy-oriented blockchain-based solutions and consensus algorithms for IoT-based green agriculture. Zhai et al. (2020) suggest that overcoming the major challenges in the implementation of agricultural decision support systems (ADSS), such as simplifying the graphical user interface (GUI), enriching decision support, adapting to uncertainty and dynamic factors, considering re-planning components, adopting expert knowledge, and historical data-based forecasting and analysis, will improve their usability and enhance sustainable and efficient agricultural practices.

Despite the numerous advantages of new technologies, the 4.0 revolution is limited to a negligible number of innovative companies in the agricultural sector (Zambon et al., 2019). Much faster progress is being made in industries on the verge of entering the 5.0 revolution. Therefore, policymakers are suggested to propose strategies and adopt measures that would encourage small and medium-sized enterprises (SMEs) to invest more in new technologies (Zambon et al., 2019).

Taking into account the essential requirements of Agriculture 4.0, this paper explores the potential applications of new technologies in the organic farming system.

Potential application of advanced ICT technologies in the organic production system

It is well known that certified organic products promote agricultural practices that responsibly address environmental concerns (Scialabba & Müller-Lindenlauf, 2010). Organic agricultural production is more efficient in the use of non-renewable energy compared to conventional agricultural production, maintains or improves soil quality, and has a lesser harmful impact on water quality and biodiversity. The implementation of smart farming techniques is recognized as one way to combat climate change, preserve the environment, and enhance agricultural sustainability. In this context, these technologies can help organic farmers manage resources more efficiently, monitor crop health, and reduce the use of synthetic fertilizers while maintaining required standards. Additionally, as research in Ethiopia has shown, smart farming technologies can contribute to increased drought resilience, yield stability, carbon sequestration, reduced greenhouse gas emissions, and increased income for small-scale farms (Zerssa et al., 2021).

With the increasing demand for organic products, consumer demands for increased supply chain transparency are also growing. Industry 4.0 technologies can facilitate product traceability by utilizing blockchain technology or other digital systems to record and verify information about product origin and production methods, thereby preserving the integrity of organic labeling and enhancing consumer awareness. Blockchain technology can also be used to create platforms that streamline the certification process and ensure the validity of issued certificates (Tegeltija et al., 2022). The advantages of blockchain include easy verification of certification data, accountability, improved risk management, visibility into trade transactions, simplified data collection and exchange, and enhanced communication (van Hilten et al., 2020).

In organic production, data-driven approaches can be used to optimize agricultural practices, improve crop yields, and reduce negative environmental impacts. For example, producers can utilize data analytics to identify patterns and make informed decisions regarding crop rotation, pest management, and soil health while adhering to organic principles. Technological solutions for crop planning can vary, from database-driven crop decision support systems to big data analytics platforms, but they need to be aligned with the level of digital literacy and skills of farmers. One enhanced application model for crop planning involves three components: crop predictor, collaboration tool, and consultation application with experts (Nordin & Faizar, 2022). Research has shown that data-driven decision-making in agriculture has the potential to enhance production in multiple ways, such as reducing yield losses, increasing farmers' profits, and eliminating unnecessary pesticide applications (Meisner et al., 2016). Various smart methods and platforms can be used for consistent monitoring of soil health, which is essential for achieving sustainable development goals (Head et al., 2020).

Agriculture 4.0 technologies enable closer connections between producers and consumers. Through online platforms, mobile applications, and social media, producers of organic products can directly communicate with consumers, sharing information about their agricultural practices, organic certifications, and sustainable initiatives. This direct communication increases consumer trust and helps promote organic products. For example, in India, a mobile application has been developed to motivate farmers to engage in organic production and inform consumers about the availability of organic products at nearby locations (Vidyavathi et al., 2020). Mobile applications can also play a role in reducing food waste, as environmentally conscious populations are inclined to purchase food through apps that sell surplus food (Doğan et al., 2023).

Are domestic producers of organic products ready for Agenda 4.0 ?

The pioneer of organic agriculture development in Serbia is Den Juro Organic d.o.o. (1985) - Brus, which specializes in the production, processing, and export of organic fruits (Ševarlić, M., 1998). The first national association for organic food is Udruženje Terra's (1990) - Subotica, which focuses on educating producers and advocating for organic production with governmental bodies (Veselinović, B., Ševarlić, M., 2000). During the time of the Federal Republic of Yugoslavia, the first Law on Organic Production was adopted in Serbia, based on IFOAM standards and EU principles (Lazić & Malešević, 2004). After the year 2000, numerous international organizations recognized the potential of organic production in Serbia and actively participated in the establishment of new associations at the local and regional levels. A significant number of domestic researchers engaged in analyzing the organic production system from various perspectives (e.g., Oljača et al., 2008; Filipović et al., 2014; Ivanović & Ivanović, 2016; Ugrenović et al., 2018; Vlahović et al., 2019; Nikolić et al., 2019; Brankov et al., 2019; Milošević et al., 2020; Milojević et al., 2021).

Despite meeting the prerequisites, including favorable agroecological conditions, the development of organic agricultural production in the Republic of Serbia has progressed relatively slowly and significantly lags behind the EU and global averages in terms of the share of land under organic agricultural production (Kovačević, 2021; Vlahović et al., 2015). The total area under organic crop production in Serbia in 2021 was 23,527 hectares, of which 13,225 hectares were certified organic, and 10,302 were in the conversion period (Ministry of Agriculture, Forestry, and Water Management, 2023). The share of land under organic agricultural production in the total agricultural land worldwide is 1.5%, in the EU it is 9.1%, while in Serbia, it is only 0.6% (Wiler et al., 2021). There are only four major producers certified for organic production, classified by the International Resource Panel (IRP) of the United Nations Environment Programme as belonging to the traditional-modern (Global Seed, Zdravo Organic, and Eco Agri) and modern food systems (Login Eko) (Brankov, 2021):

- Global Seed (2005), located in Čurug, is a member of IFOAM and the only organization in Serbia that combines organic crop production on over 2,000 hectares. They specialize in producing bulk and concentrated food for the first organic farm, which consists of around 2,000 dairy cows for organic milk production and other dairy products, as well as organic beef under the brand "Bio Panon." They have their own feed mixer, veterinary station, and bioenergy facility to address ecological, energy, and organic substrate needs for soil quality improvement and environmentally sustainable production. Global Seed also organizes an Open Day for visitors every first Saturday of the month, starting at 10 a.m., making it the only organic farm in the region to do so.

- Zdravo Organic (2007), located in Selenča, specializes in producing organic juices and other fruit and vegetable products. They achieve this through collaboration with around 150 cooperatives consisting of organic fruit and vegetable producers in the Vojvodina region.
- Eco Agri (2011), located in Bela Crkva, specializes in the production of cereals and oilseeds using a 6-year crop rotation on 1,850 hectares of certified land. Additionally, they cultivate 450 hectares of red clover, meadows, and pastures, all within a single land complex. The company incorporates green manure in their production process. Eco Agri is exclusively export-oriented, with its entire production being sold in the markets of Germany and Switzerland. The management highlights administrative barriers as one of the most significant challenges in efficient operations, specifically the documentation burden for organic products, which is ten times higher compared to conventional products.
- Login Eko (2017), based in Belgrade and Zrenjanin, is the most prepared company, both in terms of investments and human resources, to face the challenges of Industry 4.0, considering the topic of the paper.

The company Login Eko (www.logineko.com) owns 3,500 hectares of land. After a three-year conversion period, their products were first certified in accordance with the EU-BIO regulation and the BioSuisse organic standard in 2022. Various types of cereals, oilseeds, and legumes are being marketed in Germany, Switzerland, the Netherlands, Romania, Slovenia, and Serbia. To overcome market challenges caused by the conflict in Ukraine, inflation in the Eurozone, and insufficient trust in products originating from Serbia, Login Eko promotes its own product traceability system, data-driven organic production, and plant-based production without the use of animal fertilizers.

The traceability system covers the entire cycle from soil composition, treatments, seed sourcing, harvesting, to storage. They have information about all the materials they use, knowing the batches they come from and the quantities distributed across different field segments. They collect data on all field operations using various sources, from agronomist observations to automatically gathered data from machinery and drone imagery. During harvest, a unique batch label is automatically assigned, which is then tracked throughout the entire transportation and measurement process. All products are checked at a checkpoint before entering the storage facility.

After delivering the goods to customers, they take a sample from that specific batch and provide customers with a tracking report, and so on.

Organic production relies on data obtained through remote sensing techniques, drones, and satellite imagery. These data help them optimize the use of resources, including land, water, and fertilizers. Their plant-based production *without the use of animal fertilizers* is fully aligned with the Green Agenda. The company believes that by doing so, they contribute to reducing greenhouse gas emissions and mitigating soil and water resource degradation.

It is about a large estate that includes a farm and a team of software development experts who, based on data collection and traceability, provide software solutions for various specialized models. Farm management, based on a holistic "from field to table" approach, begins with a map of farm fields that provides farmers with spatial and temporal visualizations of all collected farm data, including a "elevation map" created using drones equipped with high-precision LIDAR technology that detects even tiny rocks. Elevation maps can be used in maintenance and land improvement planning, such as digging new drains and field leveling, among others. Visualizing field topography enables them to make more informed decisions regarding the implementation of appropriate agrotechnical measures that impact crop yield improvement, reduce negative environmental impacts, and increase profitability.

Special support for the application of new technologies in sustainable agriculture in Serbia is provided by BooSens Institute (2015) in Novi Sad, which has implemented 30 national and 50 international projects (https://biosens.rs). Additionally, the Supercluster AgTech Serbia brings together 17 different organizations focused on the application of high technology in agriculture and the food industry (agronews No. 3609 - 202306149). The Association for Unmanned Systems in Industry "Agrodron" (https://agrodron.rs) in Belgrade-Zemun also plays a significant role in promoting and utilizing unmanned systems in agriculture.

Conclusion

The integration of new technologies in agricultural production contributes to resource conservation, carbon emission reduction, and increased productivity. At the same time, these new technologies pose new challenges in managing agricultural production. Some of the pressing issues include digital literacy, infrastructure development, and access to technologies, data security, integration of different systems and technologies, changes in the workforce, and general acceptance of change.

Modern technologies can be applied in all types of agricultural production, including organic farming. The example of the company "Login Eko" showcases their successful implementation in managing plots and inputs for organic production, as well as recording and tracing all activities and materials used in organic production. This indicates that, despite agriculture being a sector that traditionally adopts innovations and digital technologies slowly, large producers in Serbia who are certified for organic production are leading in changes aimed at optimizing production and enhancing regional and international competitiveness.

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Analysis of the Quality of Life in Rural Areas of the Republic of Serbia Measured by the Availability of Public Services[32]

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Abstract

Quality of life is a multidimensional concept that combines different aspects of life and its quality, both tangible and intangible, objective and subjective, individual and collective. One of the key elements of quality of life is the availability and quality of public services, the spatial dimension of which is a crucial condition for increasing the quality of life of all citizens and for overcoming social exclusion and isolation. To measure the quality and availability of public services, a set of nine indicators was used, based on which rural municipalities in the Republic of Serbia were grouped. The OECD criterion was used to determine the rurality of the municipalities. Municipalities in the Republic of Serbia were divided into three groups using cluster analysis. The first cluster, the most numerous, includes the least developed municipalities. Twenty municipalities, the most developed according to three out of nine indicators, were grouped in the second cluster, while the six most populous municipalities of the Republic of Serbia were grouped in the third cluster.

Key words: quality of life, rural areas, public services, Republic of Serbia, cluster analysis

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Introduction

Quality of life is an important topic in everyday life as well as in various sciences such as philosophy, medicine, economics, psychology and others. There are a variety of definitions of the concept of quality of life, as a large number of authors from different fields of interest and research are engaged in the treatment and analysis of this topic. The concept of quality of life generally refers to the degree of well-being of an individual or a group of people (Janković et al., 2016).

Just as there is no universal definition of quality of life, there is no universal way to measure it. It is almost impossible to find two studies that use the same indicators to measure quality of life. The choice of indicators generally depends on the subjective decision of the researcher, i.e., the objectives and perspective of the research (Slavuj, 2012). Most studies divide quality of life measurement indicators into objective and subjective ones. Objective indicators refer to a person's material well-being (personal income, education level, health status, etc.) (Jokić and Čolić, 2020). Subjective indicators refer to an individual's assessment of the objective state of the environment, as only they can judge how satisfied they are with their own lives (Cummins, 1996). According to Ferriss (2010), it is necessary to comprehensively consider both subjective and objective components of quality of life, i.e. it is necessary to consider the quality of living conditions, the quality of social and physical environment as a whole.

Petovar (2006) emphasizes that the concept of quality of life also includes the quality and availability of public services, considering their spatial availability as an important condition for equitable social development and cohesion of society. Jokić and Čolić (2020) point out that the quality of life of citizens is positively related to the level of development and quality of public services. The European Union documentation, which uses the term "services of general interest" in its terminology, states that these services are "essential for increasing the quality of life of all citizens and for overcoming social exclusion and isolation ..." (CEC, 2003). Arsovski (2007), in exploring ways to measure, evaluate, and monitor quality of life, concluded that there is not enough information on quality of life indicators in Serbia. For this reason, he proposes to implement a project for measuring, evaluating and monitoring the quality of life in Serbia based on the European Union model. This model includes 29 indicators and a one third of them relate to public services.

Numerous authors emphasize the importance of high-quality and accessible public services for improving quality of life, especially in rural areas. Moser et al. (2018) studied the improvement of quality of life through rural development programs in Germany and concluded, among other things, that rural areas have deficits in the provision of public services. Josipović (2019) observes the quality of life in rural areas using social welfare indicators that allow assessment of natural conditions in rural areas, the preservation of the environment in them, and the quality and availability of public services.

The group of authors (Janković et al., 2016) studied the quality of life in rural Serbia and identified several important problems that rural residents face on a daily basis. The authors concluded that rural residents are dissatisfied with the quality of life in their communities because they have no or limited access to health care and social services, and access to pharmacies, banks, and post offices is limited due to poor transportation links. For the same reason, public service providers are not interested in offering services in these areas. This especially worsens the quality of life of elderly people who live alone, as they are significantly limited in performing activities of daily living. In addition, there are a limited number of preschools and schools in rural areas, making life difficult for families with children and encouraging young people to migrate to the cities. There are also fewer employment opportunities in rural areas than in urban areas. Access to cultural, recreational and sports facilities is also limited. From all this, it can be concluded that the poor spatial availability of public services leads to social exclusion and a deterioration in the quality of life in rural areas.

It is important to note, however, that the choice of indicators and clustering techniques can affect the results, and other approaches may yield different groupings of rural municipalities. Additionally, while digital technologies can help improve the accessibility of public services in rural areas, they may not be sufficient on their own to address broader issues of inequality and social exclusion. A comprehensive approach to improving rural development and quality of life for residents in these areas may require a combination of strategies and policies aimed at improving access to education, healthcare, infrastructure, and economic opportunities.

The potential of new digital technologies could be important for the delivery of some public services, especially in less developed and sparsely populated areas. Recently, new digital technologies have been used in education, but their application has expanded to health care and social services in developed countries. The introduction of these digital forms of services requires the establishment of a national infrastructure for digital services (Jokić and Čolić, 2020).

The aim of this research is to highlight the differences between relatively homogeneous groups of rural municipalities in the Republic of Serbia, taking into account the availability of public services as a basic condition for improving the quality of life of citizens and reducing social exclusion. For this purpose, cluster analysis was applied to data from the Statistical Office of the Republic of Serbia on rural municipalities for selected indicators, which are explained in more detail below.

Material and methods

For the purposes of this paper's analysis, a set of nine indicators has been prepared. Based on these indicators, rural municipalities in the Republic of Serbia were classified into homogeneous groups, taking into account the quality and availability of public services (Ristić, 2013; Josipović, 2019). To determine whether a specific municipality is considered rural, we used the OECD definition, according to which a municipality with a population density of less than a 150 citizens /km^2 is considered rural (Bogdanov et al., 2007). Based on this criterion, the analysis excludes the following municipalities: Beograd, Pančevo, Novi Sad, Sremski Karlovci, Temerin, Stara Pazova, Čačak, Kragujevac, Niš, and Smederevo. Since the year 2021 is the last year for which data on the majority of the observed municipalities are available, this year was analyzed. The data used in this study are taken from the official website of the Statistical Office of the Republic of Serbia.

The primary indicators used in this study to assess the quality and availability of public services are (Ristić, 2013; Josipović, 2019): the number of primary schools, the number of students in primary schools, the number of high schools, the number of citizens per doctor, the percentage of modern driveways, the number of apartments built per 1,000 citizens, the number of telephone subscribers per 1,000 citizens, the number of households connected to the water supply network, and the number of households connected to the sewage network.

Initially, the author's idea envisaged a much higher number of indicators to evaluate the quality and availability of public services. However, due to the unavailability of data at the municipal level, some indicators had to be excluded from consideration. Additionally, the number of high school students could not be obtained for 29 municipalities in the Republic of Serbia and this indicator was thus excluded from the analysis.

Data on the number of households connected to the water supply network are not available for the following municipalities: Osečina, Bogatić, Žagubica, Mali Iđos, Žitište, Malo Crniće, Nova Crnja and Žabalj. Furthermore, the municipality of Crna Trava lacks data on the number of citizens per doctor, while the municipalities of Trgovište and Plandište lack data on the number of built apartments per 1,000 citizens. Therefore, these 11 municipalities were not included in the analysis. Finally, cluster analysis was conducted on the remaining 124 rural municipalities.

Cluster analysis is a statistical interdependence technique whose main purpose is to group entities based on the similarity or dissimilarity of predetermined variables. Groups are formed in the way that each entity is similar to other entities in the group, thereby attempting to minimize within-group variance and maximize between-group variance (Carvalho et al., 2019). Effective use of clustering algorithm is largely dependent on selecting the appropriate distance measure. However, determining the suitable distance measure for a particular dataset is a challenging task (Kumar et al., 2014). A wide range of measures can be used to quantify the distance between observed entities based on all analyzed features. Among the commonly used, the Manhattan measure stands out (Wu et al., 2022). In this paper, we use this measure obtained according to the following formula (Kovačić, 1994):

$$D_{mnh} = \sum_{j=1}^{p} \left| x_{rj} - x_{sj} \right| \tag{1}$$

where x_{rj} and x_{sj} are values of indicator j for observed entities r and s, respectively.

After choosing the appropriate distance measure, the next step is to select the grouping method. Many methods for grouping entities have been developed, which can be classified into two groups: hierarchical and non-hierarchical, where the hierarchical method is more used in practice.

There are a few methods to define the proximity of entities and the most commonly used are the farthest neighbor method (Complete Linkage), the nearest neighbor method (Single Linkage), and pair group method with arithmetic mean (Average Linkage). In this research, the Average Linkage method is implemented, which is the best choice for most applications (Radojicic et al., 2022). The average linkage method is based on tracking the average of all distances of the entities belonging to the observed group, whereby the groups with the smallest average distance are combined.

Results and Discussion

Based on the observed indicators, a cluster analysis was performed and a dendrogram was created (not shown due to space limitations). Dendrogram was cut at the point of greatest distance, and the optimal number of clusters is three. It is important to note that the determination of the optimal number of clusters can also be done using a subjective method. In this analysis it was decided to keep the objective method for selecting the optimal number of clusters, since the municipalities within the same cluster are very similar in terms of observed indicators and differ significantly between clusters.

Map 1 shows the municipalities by cluster. It is important to note that the shaded municipalities are those for which data are not available, while the white municipalities are not rural and therefore were not included in the analysis.

In the following, the average values of the observed public service indicators were calculated by clusters, and the results are presented in Table 1.

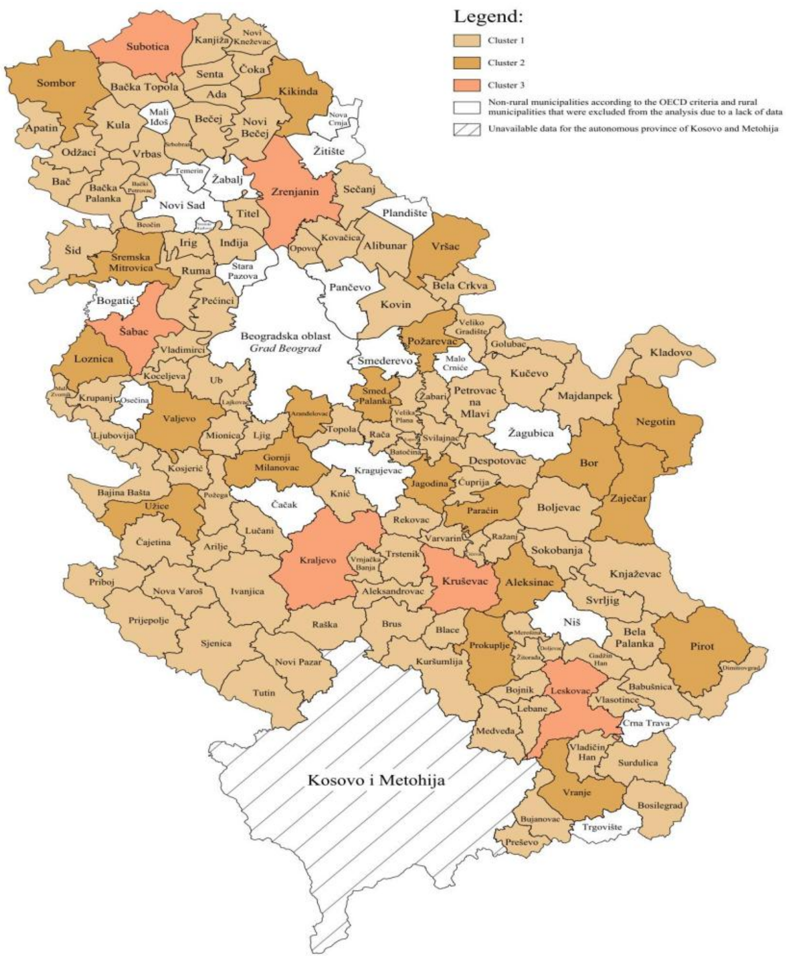
Table 1. Average values of observed indicators by clusters

Indicators	Clusters		
	I	II	III
Number of primary schools	16.23	31.55	55.67
Number of students in primary schools	1,453.47	4,086.35	8,769.00
Number of high schools	1.59	4.85	9.17
Number of citizens per doctor	680.1732	316.2151	361.7093
Percentage of modern driveways (%)	76.329%	87.356%	84.432%
Number of apartments built per 1,000 citizens	3.109	3.120	2.667
Number of telephone subscribers per 1,000 citizens	272.9471	311.3066	328.7067
Number of households connected to the water supply network	5,767.54	18,817.85	37,697.67
Number of households connected to the sewage network	3,275.26	12,640.75	28,535.17

Source: Independent work of the author

Table 1 above shows that, on average, the municipalities belonging to cluster 3 (which includes six municipalities: Subotica, Zrenjanin, Šabac, Kraljevo, Kruševac, Leskovac) have the largest number of elementary school (55.67) and secondary schools (9.17), but also students attending elementary school, 8,769. The observed municipalities also have the highest number of telephone connections (per 1,000 inhabitants) and the highest number of households connected to the water supply and sewage systems, compared to the municipalities in the first or second cluster. These data can be explained by the fact that the third cluster consists of the most populous municipalities (each of the municipalities has over 100,000 inhabitants).

Map 1. Grouping of rural municipalities of the Republic of Serbia according to the quality and availability of public services based on the observed indicators



Source: Independent work of the author

Analyzing the observed indicators for the most populous first cluster, in which 98 municipalities are located (among which are Brus, Kovin, Bečej, Novi Pazar and numerous other municipalities), in comparison with the second and third clusters, we find that there are the lowest number of schools and students, the highest number of inhabitants per doctor, the lowest percentage of modern roads and the lowest number of households connected to the water supply and sewage network.

The municipalities of the second cluster (twenty of them: Kikinda, Sombor, Pirot, Vranje etc.) are located between the first and third clusters, considering the average values for the number of schools and students, the number of telephone lines, and the number of households connected to the water supply and sewage network. However, these municipalities have the lowest number of inhabitants per doctor, the highest proportion of modern roads, and the highest number of housing units built per 1,000 inhabitants.

Conclusion

Quality of life is a broad concept that can be defined as the general well-being of people in a given society. Numerous authors have measured quality of life using various indicators. Many have studied the quality and spatial accessibility of public services as a key factor in increasing the quality of life of citizens and reducing social exclusion. Public services in the Republic of Serbia are organized in such a way that they are concentrated mainly in municipalities with high population density (municipalities of the third cluster), which has led to inequalities in access and quality of public services. As a result, some population groups are deprived of the right to public services, which leads to a lower quality of life. One way to improve access to public services in less densely populated rural communities is through the use of digital technologies.

In order to determine which municipalities are similar in terms of the quality and availability of public services, a statistical analysis was conducted, resulting in three clusters. The municipalities where inadequate access to public services was identified based on the analysis form the first cluster. These municipalities are also the most underdeveloped municipalities and the smallest in terms of population. The second cluster consists of municipalities that have the second highest population in their districts (less than 100,000 inhabitants). For most of the observed indicators, these municipalities are between the first and third clusters, while for three indicators (number of inhabitants per doctor, share of modern roads, and number of built dwellings pe inhabitants) they are at the top. The third cluster includes the most developed municipalities according to the observed indicators, which at the same time have the largest number of inhabitants and the largest area in their districts.

To determine which communities are similar in terms of quality and accessibility of public services, a statistical analysis was conducted that resulted in three clusters. The first cluster consists of the least developed municipalities, which are also the smallest in terms of population. The second cluster consists of the municipalities that are the most developed according to the observed indicators and have the second largest population in their respective districts (less than 100,000 inhabitants). The third cluster consists of the municipalities with the largest population and the largest area in their respective districts.

It should be noted that by choosing a different set of indicators or a different clustering technique, we can obtain a different type of grouping of rural municipalities in the Republic of Serbia.

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Food Security in the Republic of Serbia[36]

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Abstract

The aim of this paper is to analyze the key indicators of food security in Serbia in 2022 using the Global Food Security Index (GFSI). The indicators included in this index were compared with the global average (for the total 113 selected countries) and with the year 2019 to identify changes and key weaknesses for improving food security in Serbia.

The analysis showed that Serbia ranks 61st (out of 113 countries) in terms of food security in 2022. Looking at the individual dimensions of the GFSI, Serbia scores satisfactorily for two pillars: (1) Affordability and (2) Quality and food safety, while the lowest scoring indicators are: Food security and access policy commitments, water use (Oceans, rivers and lakes), and Disaster risk management.

Key words: Food security, the Global Food Security Index, Serbia

Introduction

Ending hunger, food insecurity, and all forms of malnutrition among the global population remain current Sustainable Development Goals. The COVID-19 pandemic has highlighted the weaknesses in agrifood systems and led to a further increase in world hunger and severe food insecurity (FAO et al., 2022). It is estimated that more than 800 million people

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suffered from hunger in 2021 (although this number has increased by about 150 million since the outbreak of the pandemic) (FAO et al., 2022). After a long period of relatively successful efforts to reduce the number of malnourished and hungry people in the world, the situation is reversing. This is the result of a number of factors, including climate change, the economic impact of the COVID-19 pandemic, and the war in Ukraine, which come on top of underlying factors such as poverty, inadequate management of natural resources, poor infrastructure, and low agricultural productivity. Combined, these factors have accelerated the spread of chronic hunger, and the trend of increasing hunger is expected to continue beyond 2023. Globally, national food systems are not adequately equipped to address these challenges and end hunger and malnutrition (IFPRI, 2022).

It is estimated that nearly 670 million people (8% of the world's population) will still be undernourished in 2030, the same percentage as in 2015 when the 2030 Agenda was adopted (UN, 2015; FAO et al., 2022). It is expected that the goals of the UN Agenda, which envisage ending hunger and ensuring food security in the world will continue to be unattainable in many countries, especially in those that are already facing these problems.

The way to overcome the problems of hunger and food insecurity is through greater investment, or more significant investment by individual countries, in agricultural and food systems. Global support for agricultural development and improved food production totaled nearly US$ 630 billion per year in 2013-2018. However, a significant proportion of this support is environmentally destructive, distorts market prices, harms small-scale producers, and does not contribute to better nutrition for children and other vulnerable categories of the population (FAO et al., 2022).

The aim of this paper is to analyze food security and its dimensions using the Global Food Security Index (GFSI) in Serbia in 2019-2022. In particular, the GFSI indicators that represent weaknesses, i.e. limiting factors for improving food security in Serbia, are analyzed.

Materials and methods

The selection of indicators to measure food security is a very complex task. As the concept of food security has changed and the number of dimensions included has increased, the number and types of indicators used to measure these aspects have also changed (Pangaribowo et al., 2013). The most commonly used indicators to measure food (in)security are: FAO hunger index; Global Hunger Index (GHI), and Global Food Security Index (Božić and Papić, 2019).

The Global Food Security Index (GFSI) is an annual index created by the Economist Intelligence Unit (EIU) for 113 selected countries, including the Republic of Serbia, since 2012. Its purpose is to comprehensively measure and monitor food security and its components in individual countries worldwide. In this paper, food security in Serbia was analyzed using GFSI, which provides an overview of the most important indicators and their impact on food security. In addition to the analysis of documents, a comparative method was used to compare food security in the Republic of Serbia with the global average, but also to analyze the time dimension by comparing the year 2022 with the pre-crisis year 2019.

In addition to the annual reports of the GFSI, for the preparation of this paper were used the database of EIU and numerous publications of institutions dealing with food safety issues, such as: FAO, IFPRI, UN, and papers of domestic and foreign authors.

Theoretical framework of research

Food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (FAO, 1996; Peng & Beri, 2019). The analysis of food security is a complex problem that can be considered on an individual or higher, national level (Allee et al., 2021).

There are a large number of indicators to measure food security. Following the food crises in 2008 and 2011, the EIU constructed the Global Food Security Index in 2012, which measures food security at the national level to identify which countries are most and least vulnerable to food insecurity (Božić & Nikolić, 2020).

Unlike other indicators that focus on an individual and his or her experience in ensuring food security, the GFSI is country-centered and takes into account a large number of weighted indicators with the goal of measuring national capacity to ensure food security for its own population (Allee et al., 2021). The GFSI uses a number of indicators to cover broad aspects of food security, grouped into four pillars: (1) Affordability, (2) Availability, (3) Quality and safety, and (4) Sustainability and adaptation. *Affordability* measures the ability of consumers to purchase food, their vulnerability to price volatility, and the presence of food programmes and policies. *Availability* of food is measured by the volume of agricultural production and access to inputs, on-farm capabilities, agricultural research and development, and food losses. *Quality and safety* measures the variety and quality of nutrition as well as the safety of food. *Sustainability and adaptation* assesses a country's exposure to the impacts of climate change, the risks to which natural resources are exposed, but also how the country is adapting to these risks, i.e. the extent to which there is political will for such action (Table 1).

Table 1. Conceptural framework of the GFSI in 2022 iteration

Affordability	Availability	Quality & Safety	Sustainability & adaptation
1.1 Change in average food costs	2.1 Access to agricultural inputs	3.1 Dietary diversity	4.1 Exposure
1.2 Proportion of population under global poverty line	2.2 Agricultural research & development	3.2 Nutritional standards	4.2 Water
1.3 Inequality-adjusted income index	2.3 Farm infrastructure	3.3 Micronutrient availability	4.3 Land
1.4 Agricultural trade	2.4 Volatility of agricultural production	3.4 Protein quality	4.4 Oceans, rivers and lakes
1.5 Food safety net programmes	2.5 Food loss	3.5 Food safety	4.5 Political commitment to adaptation
	2.6 Supply chain infrastructure		4.6 Disaster risk management
	2.7 Sufficiency of supply		
	2.8 Political and social barriers to access		
	2.9 Food security and access policy commitments		

Source: Systematization of authors based on Economist Group, 2022.

Results and Discussion

Analysis of food security in Serbia

The Global Food Security Index shows that the global food environment is deteriorating including production and distribution of food globally. After hitting its peak in 2019, the values of this index are rapidly decreasing due to the Covid-19 pandemic, the war in Ukraine, and 'skyrocketing food prices and hunger on an unprecedented scale' (GFSI, 2022).

The value of the GFSI on global level in 2022 was 62.2 (Table 2). Serbia was ranked on 61th place with score of 61.4, which means that the food security index has slightly increased (by 0.5%) compared to 2019. Among European countries, Serbia occupies the penultimate position and is ranked 25th while only Ukraine is ranked on lower position. Serbia has a 1.3% lower GFSI value compared to the global average (for 113 countries), i.e. a 27% lower index value than the best ranked Finland, indicating that there are significant opportunities to improve the food system.

Tabela 2. GFSI of top five countries in the world and Serbia in 2022

Country	Score	Change 2022/2019	Rank all countries	Rank Europe
All countries	62.2	-0,4	-	-
Finland	83.7	+0.1	1	1
Ireland	81.7	-1.0	2	2
Norway	80.5	-1.2	3	3
France	80.2	+2.3	4	4
Netherlands	80.1	-0.8	5	5
Serbia	**61.4**	**+0.5**	**61**	**25**

Source: Authors' processing and interpretation of data based on EIU database

Analysis of food security by specific pillars (Affordability, Availability, Quality and safety and Sustainability and adaptation) shows that not all factors are equally important and that Serbia scores positively on some of these factors while others score poorly (Table 3). For the first pillar of the GFSI (*Accessibility*), Serbia ranks on 43rd place, with a score of 81.5 (the best score and ranking of all four pillars). It should be noted that the value of this pillar has decreased compared to 2019 (by 1.3%).

Table 3. Values of GFSI and its dimensions for Serbia and all countries (average)

	Serbia			All countries, average
	Score 2022	Change in score 2022/2019	Rank 2022	Score 2022
Overall	61.4	+0.5	61	62.2
Affordability	81.5	-1.3	43	69.0
Availability	49.3	+7.4	89	57.8
Quality and Safety	72.6	-7.3	45	65.9
Sustainability and adaptation	37.0	-3.2	107	54.1

Source: EIU database and GFSI report for 2022, Economist Group, 2022

For the second pillar of the GFSI - *Availability* - Serbia scored 49.3 in 2022 (despite an increase of 7.4% compared to 2019), and was ranked significantly lower than for the first pillar, in 89th place. The largest decrease compared to 2019 was recorded for *Quality and safety of food,* where Serbia ranked 45th with a score of 72.6. The lowest score was recorded for *Sustainability and adaptation* to the climate change (37.0), where Serbia ranked 107th out of 113 countries.

Compared to the average for all countries, Serbia has a lower overall level of food security. When broken down by component, two pillars (Accessibility and Quality and safety) had a better score, while scores for pillars Availability and Sustainability and adaptation were below the global average, and there are opportunities to improve food security.

Analysis of basic indicators of food security in Serbia – strengths and weaknesses

In this part of the paper, an analysis of the indicators within the pillars of food security is made, which provides the opportunity to single out those indicators that contribute to the improvement and stability of the food system and those that represent the major weaknesses.

Among the indicators that have a score above 75 in 2022, and thus are labelled as "strengths" and contribute to improving food safety, seven indicators were included, all of which were also the strongest aspects of food safety in 2019 (Table 4).

Table 4. Food security indicators in Serbia that represent the strengths*

	Indicator	2019	2022	
		Score	Score	All countries average
1.1	Change in average food cost	90.5	77.5	70.7
1.2	Proportion of population under global poverty line	91.0	95.9	83.5
1.5	Presence and quality of food safety net programmes	100.0	100.0	72.4
2.5	Food loss	86.4	85.7	75.5
3.4	Protein quality	82.0	83.7	68.5
3.5	Food safety	92.3	92.8	76.4
4.3	Land	77.5	76.5	61.3

*"Strengths" are defined as indicators with score above 75.0 (EIU Database, GFSI 2019)

Source: Authors' calculation and interpretation of data based on EIU Database and GFSI reports for 2019 and 2022 (EIU, 2019; EIU, 2022)

Among the indicators representing the "strengths", i.e. the factors improving food security in Serbia, the highest value (maximum score – 100) in both observed years is the *Food safety net programmes*. This composite indicator analyzes whether there are programs to provide sufficient quantities of food for all categories of the population (especially the vulnerable ones) and whether these programs have nationwide coverage and financial independence. Also included under "strengths" is an indicator that measures the *Proportion of population under global poverty line*, calculated as the percentage of the population living on less than USD 3.20 per day, expressed in purchasing power parity (PPP for 2011). The indicator measuring the change in average food prices was better rated in 2019, and the decrease in the score for this indicator is a result of the increase in food prices and the change in the average food cost of the average market basket of food products. Nevertheless, Serbia is still above the global average. At the same time, the *Average food costs*, i.e. food expenditure per capita, is the main factor determining food security, significantly more than other indicators included in the GFSI, such as the volume of agricultural production, food quality, distribution, and similar (Allee et al., 2021).

Of the indicators of the second pillar (*Availability*), only the indicator *Food loss* was identified as a strength meaning that there are no significant and unnecessary food losses. Of the third pillar indicators, the indicators *Protein quality* and *Food safety* were rated highly, with the first referring to the quality of protein included in the diet and the second referring to the conditions for ensuring food safety. Both indicators recorded a slight increase in 2022. Of the indicators in the fourth pillar (*Sustainability and adaptation*), only one – *Land* is classified as "strengths". This indicator addresses the quality and health of the land, as well as the degree and the impact of its degradation on agriculture. All of the above indicators assessed as "strengths" of food security in Serbia have higher values than the average of the 113 countries included in the GFSI calculation.

The second group of indicators consists of those with scores between 25 and 75 that have a medium impact on food security. A total of 13 such indicators were identified (Table 5).

Table 5. Food security indicators in Serbia which have medium* impact

	Indicator	2019	2022	
		Score	Score	All countries, average
1.3	Inequality – adjusted income index	54.3	59.1	55.5
1.4	Agricultural trade	71.7	71.7	67.6
2.1	Access to agricultural inputs	58.2	72.2	57.6
2.3	Farm infrastructure	58.1	57.2	55.7
2.4	Volatillity of agricultural production	10.2	30.6	68.7
2.6	Supply chain infrastructure	52.7	51.1	47.8
2.7	Sufficiency of supply	21.4	71.2	61.9
2.8	Political and social barriers to access	63.2	59.8	58.7
3.1	Dietary diversity	58.8	59.0	52.5
3.2	Nutritional standards	100.0	61.3	63.7
3.3	Micronutrient availability	65.2	65.2	67.8
4.1	Exposure	66.3	66.3	67.9
4.5	Political commitment to adaptation	22.4	40.4	55.8

*Indicators with score ranging from 25.0 i 75.0

Source: Authors' calculation and interpretation of data based on EIU Database and GFSI reports for 2019 and 2022 (EIU, 2019; EIU, 2022)

The first pillar indicators (*Adjusted income index* and *Agricultural trade*) remained almost unchanged during the observed period. Most of the indicators belong to the second pillar - *Availability*, with the indicators *Access to agricultural inputs* and *Sufficiency of supply* showing the largest increase. The 14% increase in the first indicator is due to better access to financial sources, extension services and cooperative organizations. *Sufficiency of food supply* and *Volatillity of agricultural production* indicators were rated as "weaknesses" in 2019 (scores below 25.0), while their impact on food security was rated as moderately important in 2022.

From the third pillar, related to *Quality and safety* of food, three indicators were included, two of which (*Dietary diversity* and *Micronutrient availability*) remained almost unchanged, while the indicator *Nutritional standards* recorded a lower score and was moved from "strength" to the middle group. This indicator reviews the activities of government institutions in publishing and implementing nutrition guidelines, requiring packaged foods to include nutrition labelling information, etc. Two indicators from the fourth pillar were rated as of medium importance. *Exposure to climate change* remained unchanged in both monitoring years, while the indicator *Political commitment to adaptation*, which was classified as "weakness" in 2019, was transferred to this group due to a higher score due to improved measures related to mitigating climate change.

More than half of the above indicators with medium impact on food security in Serbia have scores above the global average, while five have lower scores, with the lowest scores for *Volatillity of agricultural production* (30.6) and *Political commitment to adaptation* (40.4).

The last group of indicators consists of those with scores below 25.0, which are considered “weaknesses” in food security. According to the GFSI, there were five such indicators for Serbia in 2022 (Table 6).

Tabela 6. Food security indicators in Serbia that represent weaknesses*

Indicator		2019	2022	
		Score	Score	All countries, average
2.2	Agricultural research and development	37.8	23.1	47.1
2.9	Food security and access policy commitments	0.0	0.0	47.1
4.2	Water	25.0	25.0	41.2
4.4	Oceans, rivers and lakes	6.1	6.1	41.5
4.6	Disaster risk management	2.4	2.4	55.7

*“Wasknesses” are defined as indicators with score less than 75 (EIU Database, GFSI 2019)

Source: Authors’ calculation and interpretation of data based on EIU Database and GFSI reports for 2019 and 2022 (EIU, 2019; EIU, 2022)

All indicators in this group (with the exception of *Agricultural research and development*) had unchanged scores in 2022 compared to the previous year. Research and development in agriculture consists of two sub-indicators. First, state expenditure on research and development in agriculture in Serbia (23.7) is low and below the global average. Second, value for commitment to innovative technologies that contribute to the development of sustainable agricultural systems and increase productivity, in 2022 on global level was 54.9, but for Serbia it was zero, which indicates insufficient commitment to the development of innovative technologies in Serbian agriculture. The indicator *Food security and access policy commitments* has a value of 0.0, which means that there is no monitoring body or national food strategy in Serbia that would make food security a focus area and priority. It is a worrying fact that the number of food security indicators classified as weaknesses has increased significantly compared to 2013, when there was only one indicator in this category (Papić and Milovanović, 2015).

Among the indicators that represent weaknesses and limitations for food system development and food security are three that belong to the pillar *Sustainability and adaptation*. Among them, the indicator with the highest score is *Water* (25.0), a complex index related to overall water availability and the level of water pollution. The indicators *Rivers and lakes* and

Disaster risk management are among the lowest scoring indicators (scores of 6.1 and 2.4, respectively) and are significantly below the global average (41.5 and 55.7, respectively). They refer to the disruption of ecosystems and biodiversity, adaptation and mitigation measures that help to reduce the risk of pests infestation, and mitigation and reduction of the impact of natural disasters, which can also affect agricultural productivity, but these measures are not sufficiently represented in Serbian practice.

Conclusion

Numerous structural problems and risks in the global food system, which include volatility of agricultural production, limited natural resources, increasing economic inequality, and socio-political events of recent years, affect the food security of certain countries, including Serbia.

Various indicators are used to measure food security, and one of them is the Global Food Security Index. Measured by this indicator, Serbia ranked 61st in terms of food security in 2022 (out of 113 countries) with a GFSI score of 61.4, which is a slight increase (by 0.8%) compared to 2019.

When broken down by individual dimensions of the GFSI, Serbia has the highest scores for the pillar *Affordability* of food (81.5), followed by *Quality and safety* of food (72.6), and lower scores for *Availability* (49.3) and *Sustainability and adaptation* (37.0). The lowest scoring indicators that represent constraints to improving food security in Serbia are *Agricultural research and development* (23.1), *Food security and access policy commitments* (0.0), and three indicators related to natural resources within the pillar *Sustainability and adaptation* (*Disaster risk management; Rivers and lakes*, and *Water*).

The insufficient or total lack of commitment to research and development of innovative technologies in agriculture, policies focused on food security, conservation of natural resources, and coping with natural disasters highlight the need for greater investment in agricultural research and development. Creating sustainable agricultural production systems helps farmers to increase their productivity, contributes to the conservation of natural resources, the provision of sufficient quantities of agricultural products, and thus improves the overall food system in Serbia.

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Interdependce of Agriculture and Tourism Business in Rural Areas of Serbia

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Abstract

The main goal of the work is to point out the importance of business in rural tourism, which can contribute to the strengthening of economic activities and revitalization of rural areas, based on research on the interdependce of agriculture and rural tourism in the Republic of Serbia. Based on the analysis of observed interdependence, it was concluded that tourism and tourist business could represent a significant supplementary activity of rural farms and a supplementary source of income. A more intensive development of agritourism should certainly contribute to strengthening the economic position and raising the standard of living of the agricultural population as the most significant segment of the rural population.

Keywords: Agriculture, rural tourism, natural resources, economic development

Introduction

The interdependence of agriculture and rural tourism is the subject of frequent theoretical discussions and scientific observations. There is a high degree of agreement that these are two complementary and multiple related activities. Their connection is explained by the fact that agriculture is a source of food for the tourist market and that the development of tourism

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contributes to the revitalization of rural areas. Therefore, these are activities that naturally complement each other, with agriculture appearing in the role of producers of agricultural products, and tourism, i.e. tourist demand, in the role of end consumers. It is estimated that the role of agriculture in the development of tourism can be multifunctional - agriculture as a source of food, raw materials and additional labor, but also as a carrier of tourism development and a motive for tourist movements. Bearing in mind the positive effects of this model of connection between agriculture and tourism, it can be concluded that the benefits of strengthening that connection can be, first of all, for rural agricultural households, local communities, as well as the rural economy as a whole.

The theoretical elaboration and set task decided us to use the descriptive, comparative-historical and analytical-synthetic method on the work, as well as content analysis.

Research results and discussions

State, problems and objectives of the development of agriculture in Serbia

Agriculture represents a very important component of the overall economy of the Republic of Serbia. In agriculture, as an important economic activity, primary products of suitable vegetable or animal origin are obtained by using land, growing plants and animals. In addition, agriculture usually includes their processing in order to bring these products to a state where they can satisfy some need (personal or reproductive). Agriculture fulfills numerous tasks: provides food; provides raw materials for many areas of the processing industry (production of food products and beverages, production of tobacco products, production of textiles, leather and footwear industry, etc.) and for crafts; conditions the development of industry using a good part of industrial products, providing the necessary workforce and part of the accumulation for its initial development; affects the balance of foreign trade by creating a significant part of products for export, primarily in the initial phase of industrialization, although agricultural raw materials and food can be significant items in imports as well (Devetaković et al., 2021, p. 63).

Agricultural production is characterized by certain specificities, such as: high dependence on natural conditions (land, relief, soil configuration, climate, etc.), which leads to larger or smaller jumps/falls in production, greater business risks and instability of farmers' earnings; the production process is predominantly related to land, which creates certain organizational-technological and socio-economic problems (fragmentation or consolidation of agricultural holdings, which is conditioned by land ownership); the basis of agriculture is organic production, the products of which are, as a rule, the living world, which is why the procedures, organization and economy are adapted to the biological conditions and characteristics of plants and animals, and this enables a much larger mass of agricultural products to be obtained from the initial living material. In addition, the time of the production process usually does not coincide with the nature of human work, so in production several different products are combined whose production time and working period are different, and thus a specific division of labor and mutual complementation in this area is carried out (Devetaković et al., 2021, p. 64).

The structure of agricultural production and its proper determination implies long-term solutions. In agriculture, unlike industry, it is not possible to easily and quickly change the structure of production, due to the fact that a longer period of time is needed to reorientate production and adapt it to market requirements (e.g. in fruit growing, viticulture, etc.), which indicates the need adequate planning of the production structure. Agriculture, due to its connection and influence on other sectors of the economy, is extremely important for the development of the Republic of Serbia. It employs, directly or indirectly, a large number of people, takes a significant part in the country's foreign trade, ensures the food security of citizens, contributes to rural development and ecological balance. Due to its great influence on the overall economic activity, agriculture and the food industry represent one of the priorities in the overall economic development of Serbia. This area achieves a significant foreign exchange inflow from exports, which positively affects the country's balance of payments and the stability of the exchange rate, it can recover faster and influence the mitigation of the consequences of the world economic crisis. The sector of agriculture, forestry and fishing participates to a significant extent in the creation of the country's gross added value. However, if we look at the entire agribusiness complex of the country, which includes suppliers of agriculture with necessary inputs for production, industries that use agricultural products as raw materials in their production, this participation is much higher. Due to its natural characteristics of the soil (5.1 million hectares of agricultural land, mainly adequate physical and chemical characteristics for intensive production), climate (temperate-continental) and water resources (600-800 mm of precipitation in the plains, i.e. 800-1200 mm in mountainous areas with a relatively branched water course) The Republic of Serbia has a great potential in the agricultural sector, which has not been fully utilized.

Agriculture in the Republic of Serbia faces many problems. They are, among other things, a consequence of limitations created in the earlier period of development of our country and transitional difficulties in adapting to the market economy. The biggest problems of domestic agriculture are extremely low productivity, unfavorable competitiveness on the domestic and foreign markets and extremely low profitability. Serbian agriculture is characterized by the fragmentation of agricultural holdings and their high parcelization (the average size of the farm is below 3 ha with an average of 7 plots compared to 18.6 in the EU, which negatively affects the competitiveness of agricultural holdings), relatively well equipped with agricultural mechanization (nevertheless, agricultural mechanization is outdated, so, for example, the average age of mechanization on agricultural farms is over 20 years), low use of artificial fertilizers as well as extremely low productivity in almost all areas of production. Average yields in agriculture are, for the most part, far below the EU level. The process of privatization in the agricultural sector has so far proceeded slowly, with little foreign investment. There are problems in the management domain as well, and they are reflected in the absence of the desire of the new management to undertake significant investment activities in the development of primary production and processing, it is more oriented towards short-term profit. The agrarian budget tries to solve a difficult task with limited funds in the form of quantitative and qualitative improvement of domestic agricultural production, in order to increase its competitiveness on the domestic and foreign markets. The predominant source of investment in agriculture since the mid-nineties of the last century comes from the agrarian budget, which is extremely important for the rural population and the producers who live from this production. In today's conditions, no agricultural producer can survive without state protection and subsidies. Credit conditions for agricultural production in our country are still unfavorable. If the mechanism of crediting agricultural production with budget funds is excluded, it is evident that, with the exception of rare commercial banks, the agricultural credit market still cannot meet the needs of domestic agriculture with available funds and market interest rates.

Expressed development problems of agriculture require a new concept and an effective development policy based on the economically rational activation of the total development potential of domestic agriculture. Starting from the current state of our agriculture and trends in economic movements, as well as realistically assessed conditions and development opportunities, the national strategy for the development of agriculture in the coming period is aimed at achieving the following interconnected goals: build a sustainable and efficient agricultural sector that can compete on the world market, contributing to the increase in national income; to provide food that meets the needs of consumers in terms of quality and safety; ensure support for the standard of living for people who depend on agriculture and are unable to follow economic reforms with their development; ensure support for the sustainable development of villages; save the environment from the effects of agricultural production; prepare the agriculture of the Republic of Serbia for integration into the EU (the priority task of our agriculture is the signing of international agreements, which will primarily aim at security in investments, defining a clear policy and integration into the EU market); prepare a policy of domestic support and trade in agriculture for WTO rules; improve the organization of agricultural producers at all levels; creating an efficient and effective land market; creation of efficient and effective institutions for the acquisition and transfer of knowledge in the field of agriculture.

Geographical location and natural resources as factors in the development of agriculture and rural tourism

Geographical position (location) and natural resources are cited as basic natural conditions for agricultural production. The country's geographical position and natural resources are important factors that influence the pace of the overall economic development of a country. Geographical location, with all its characteristics, significantly determines the suitability of a certain area for farming. Climate through the number of hours of sunshine, volume and type of precipitation, temperature levels in different time periods, the influence of water and wind significantly determine the suitability of a certain area for farming as well as the choice of methods and results of agricultural production. Geographical position is expressed by the geospatial coordinates of a country, i.e. latitude and longitude, but also characterized by altitude, distance from large seas and land, borders and the shape of the area in question, as well as distance from modern economic, political and cultural centers and world traffic corridors. . Therefore, the geographical position of a country cannot be valued only from the point of view of physical characteristics. It has economic, political and sociocultural content, so it is neither an abstract nor a static category. The Republic of Serbia has a very favorable geographical position. The favorable natural-geographical and traffic position of the Republic of Serbia is an advantage for the development and efficient functioning of river, land and air transport and a prerequisite for attracting significant transit traffic. The proximity of the current and future EU members from Southeast Europe, the geostrategic position and the infrastructural connection of the Republic of Serbia with the countries of the region (Balkans), subregion (Southeastern Europe) and the EU, represent a real advantage for the faster political and economic integration of the Republic of Serbia in these geoeconomic and regional integrations. The Republic of Serbia covers a territory of 88,361 square kilometers, of which: Central Serbia 55,968 square km, Vojvodina 21,506 square km and Kosovo and Metohija 10,887 square km.2 Serbia is located in the center of the Balkans, at the intersection of the main pan-European traffic corridors 7 (Danube River) and 10 (road and railway). Through its territory, there are naturally, the shortest and most rational transit road and rail connections between the countries of Central and Western Europe and the countries of the southern part of Europe, the Middle and the Far East.

In addition to geographical location, natural resources also play an important role in the development of the economies of most countries in the modern world. The importance of natural resources for the economy of a country is conditioned by the degree of its economic and technological development, features of the built economic structure and the place of a given economy in the international division of labor. According to their character, natural resources can be renewable and non-renewable. Renewable natural resources include those resources that man can renew and increase to some extent through his activity. This is the case with land and forests. When it comes to non-renewable resources, such as mineral resources, human activity is limited only to their adequate use. The resource policy of each country must take into account that the management of natural resources must be carried out in a way that ensures their ecologically rational exploitation. Differences in the availability of natural resources can be the cause of a higher level of living standards in certain countries. Some oil-rich countries (Kuwait, Saudi Arabia) have a higher standard of living thanks to this fact. However, many development studies today almost unanimously indicate that the lack of natural resources is not a significant constraint on economic growth. There are numerous examples of resource-poor countries that have achieved strong economic growth despite this. Japan, for example, is one of the leading economies of the modern world, although it has very modest natural resources. However, in conditions of global energy and raw material scarcity, there is an increase in the absolute and relative importance of natural resources for the production dynamics of each national economy.

The territory of Serbia is characterized by favorable natural conditions, significant agricultural area, wealth of forest and water, tourist attractiveness and resource diversity of the area. The moderate continental climate, the productive structure of land surfaces, the geological composition of the area with deposits of metal and non-metal ores of different quality and suitability for exploitation, form a natural basis for various economic activities. Serbia has a rich biodiversity thanks to the developed relief and geological, pedological and climatic conditions. It has 130 plant species that are protected natural rarities. The most significant is the forest plant vegetation (endemic plants and forest fruits, various medicinal plants and forest fruits) and the vegetation of lower plants (meadows and pastures). A variety of plant vegetation and climatic conditions have enabled the existence of various animal species that are particularly important for hunting and hunting tourism. Serbia has 690 animal species (domestic animals, game, birds, fish) that are natural rarities. Agricultural land in Serbia is 5.1 million hectares, of which 3.3 million hectares are arable land. The soil quality is above the European average, which enables Serbia to be a significant producer of biologically healthy food. The concept of organic agricultural production is implemented in several locations in the form of various products. The area under forests in Serbia is 1.9 million hectares, and the degree of forest cover is about 0.24 hectares per inhabitant, which is above the European average (0.20 hectares per inhabitant).

Serbia has significant water potential (surface and underground water, lakes) for the supply of settlements, industrial needs, irrigation of fertile arable land and development of overall economic activities. The length of the river courses is 3,672 km, of which 1,420 km are navigable, and the length of the Bač and Banat canals is 673 navigable km. The surface of the lake and reservoir is about 829.5 km². River courses contain significant hydro potential, which is largely under exploitation. Built hydroelectric power plants produce about 10 billion. kWh of electricity. Water wealth occurs in all forms, primarily due to the characteristics of climatic and geological factors. From the point of view of economic activities, the territorial distribution of water is unfavorable, and water pollution increases with the growth of consumption.

Serbia has significant natural energy potential (primary forms of energy) with a specific structure characterized by the dominant participation of lignite and significant hydro potential. Geological reserves of energy raw materials amount to about 5.1 billion. tons of equivalent coal. The largest part of the total energy raw materials is coal, with a share of about 85%, while a small part refers to crude oil and natural gas 5.3%, oil shale 6.5% and uranium ore 3.2%. Serbia also has significant opportunities for new sources of energy, such as biomass, small hydropower plants, solar and wind energy. Geological reserves of coal are estimated at around 14.8 billion. tons, of which balance reserves amount to 35.4%. Of the total balance reserves, exploitation reserves make up 64%. In the structure of coal balance reserves, the share of lignite is 85%, hard coal 0.5%, brown coal 1.5% and brown coal 11.9%. Serbia has significant ore wealth of non-ferrous metals (copper, lead and zinc), which is the basis for the production and processing of non-ferrous metals. Deposits of non-metallic raw materials (magnesite, refractory and ceramic clay, cement marl, brick clay, quartz raw materials, etc.) are also significant, which are the raw material base for the production of non-metals and building materials.

The connection between agriculture and business in rural tourism

Thanks to the favorable natural conditions for the development of tourism, Serbia can become an important tourist country in terms of the number of tourists and foreign exchange income. The development of tourism is based on exceptional conditions in the continental part of the country (numerous landforms, mountain and plain rivers and lakes, diversity of vegetation decor, long-term snow cover, built physical culture facilities and improved traffic conditions). Considering that the activities of tourism and agriculture are related to the same area, its level of development and preservation, as well as living conditions, directly affect their development (Žilić, 2020). One of the main trends in the transformation of modern agriculture is the integration of modern agriculture and rural tourism (Yi et al., 2019). In the literature, the connection between agriculture and tourism is the subject of frequent discussions. There is a high degree of agreement that these are two complementary and multiple related activities. The multiple connection is explained by the fact that agriculture is a source of food for the tourist market; that the revival of tourism contributes to the revival of rural areas; to operate in the same area, the preservation of which is in the common interest. Therefore, these are activities that naturally complement each other, with agriculture appearing in the role of producers of agricultural products, and tourism, i.e. tourist demand, in the role of end consumers. It is estimated that the role of agriculture in the development of tourism can be multifunctional - agriculture as a source of food, raw materials and additional labor, and as a carrier of tourism development and a motive for tourist movements. Bearing in mind the positive effects of this model of connection between agriculture and tourism, it can be concluded that the benefits of strengthening that connection can be, first of all, for rural agricultural households, local communities, as well as the rural economy as a whole. According to Tonković, the rural area is multifunctional, and its primary role, apart from food production, is the preservation of the rural landscape, the protection of biodiversity, and thus the creation of jobs, and the result is a certain level of self-sustainability.

The need for diversification of economic activities in rural areas that show great dependence on agriculture, as well as the possible role of tourism in this process and its connection with agriculture, is recognized in our strategic documents (Bošković, 2013, p. 220). Diversification of economic activities represents a way for the survival of every rural environment and the struggle to survive in conditions of weak market development and low investment of capital and funds (Ćurčić et al, 2021). The direct connection and mutual dependence of agriculture and tourism is most noticeable in agrotourism, as the most important segment of the tourist offer of rural areas. The development of this type of rural tourism is linked to the development of tourism on rural agricultural farms, which have the conditions to, in addition to agricultural production as a basic activity, offer food and/or accommodation services to tourists. The development of tourism in rural areas creates conditions for the owners of agricultural holdings, with minimal investments in adapting their existing facilities to accommodate tourists, to provide themselves with additional income from tourism. In this way, along with agriculture as the primary source of income, they also introduce tourism as a supplement to household income. According to Kataya, it can be said that rural tourism must become an alternative for the problem of agriculture and rural areas. Rural tourism combines different components of rural areas, such as: economic, social, environmental (Yang, et al., 2021). The development of tourism on agricultural farms brings the owners income from tourist services, and also creates the possibility for the farm to sell products from its agricultural production "at the doorstep". From the above, it is clearly visible the close mutual connection and conditioning of agriculture and agro-tourism. The development of agritourism, that is, the inclusion of an increasing number of agricultural farms in tourist activities, has a positive effect on the development of agriculture. On the other hand, the development of agriculture, i.e. the increase in the number of agricultural holdings, represents a good basis for more intensive development of agritourism. The main advantage of tourism development within agricultural households is: providing income from tourism in rural areas with minimal investment, as well as expanding economic development in peripheral areas based on the interdependence of agriculture and tourism (Čomić, 2002, p. 119). However, future development should not be directed towards agricultural farms completely reorienting themselves to tourism, but rather that their basic activity should continue to be engaged in agricultural production. In the rural economy, tourism is an additional source of income, and the quality of service is most often based on an organized and comprehensive offer (Kovačićek, et al., 2021). Therefore, agriculture should continue to be the primary source of income, and tourism should only be a supplementary activity of rural farms, i.e. a supplementary source of income. A more intensive development of agritourism should certainly contribute to strengthening the economic position and raising the standard of living of the agricultural population as the most significant segment of the rural population. Based on such expectations related to the improvement of economic living conditions in rural areas, in the future it would be possible to expect other positive changes (primarily, in the demographic sphere). Rural tourism is recognized in the literature as a significant factor in the activation and sustainable development of rural areas (Sudarić et al., 2018). Rural tourism and agritourism provide an active interconnection of agricultural activities and regional traditions for efficient use of the area's natural potential and contribute to regional development (Mura et al., 2018).

Achieving the previously mentioned positive effects will depend on the creation of conditions for more intensive development of agriculture and agritourism. The main limitation is the insufficient size and fragmentation of the agricultural land of rural households. The consolidation process would have a positive impact on the development of agriculture, but also on the development of agritourism. Also, the unfavorable circumstance that was already mentioned earlier is the continuous reduction of the share of agriculture in the total population. However, there are other limiting factors in the development of the relationship between agriculture and tourism. First of all, these are limitations within the household itself, such as: absence of ambient tourism value of the household, insufficiently developed additional tourist offer, absence of food offer of defined geographical origin, disorganized households, lack of association and joint performance, and others. Likewise, limitations can be observed outside the agritourism household itself, namely in the area of legal regulations, marketing support and others. Activities that are proposed with the aim of removing restrictions and strengthening the link between agriculture and tourism are: creating and supporting a common vision for future development; identifying common and priority problems; development of a strategy for providing mutual support; education of households on the way of accepting and hosting tourists; development of a tourist product that will include the agricultural segment (inclusion of the agricultural segment in additional activities on the farm); establishment of village tourist points, undertaking targeted marketing activities, intensification of the construction of the missing rural infrastructure, construction of new or renovation of existing sports and recreational grounds in rural areas, activation of old trades and handicrafts (Todorović, M., Štetić, S., 2009, p. 31).

Conclusion

Analyzing the interdependence of agriculture and rural tourism, it is clear that multiple benefits arise from their connection, both for one activity and for the other, and that, overall, this has a positive impact on the overall development of rural areas. For these reasons, in the future we should work on creating stimulating conditions for strengthening this relationship and achieving maximum benefits for all participants in this relationship in the rural area of the Republic of Serbia, as an area that is very suitable for the development of both mentioned activities. Multifunctional development should enable the faster development of Serbian agriculture, as well as strengthening its competitive position in the future. This means that part of the agricultural resource is used in a conventional way; part of the resources for non-agricultural purposes (rural tourism, especially agrotourism and other services and the production of renewable energy), and to put part of the resources into the function of producing organic and health-safe food.

The production of organic and health-safe food, in addition to being a promising product from the aspect of world demand for these products, is also in accordance with the modern demands of tourist demand. Namely, there is an increasing orientation of tourist consumers to the market of ecological food production, so that the determination of agricultural producers for this type of production can additionally strengthen the connection between agriculture and tourism.

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Market of Viticulture and Wine in the Republic of Serbia

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Abstract

The subject and objectives of the research are to examine the trends and structure of wine exports and imports in the Republic of Serbia, with a focus on the key parameters of these indicators. The data sources used are from the Statistical Office of the Republic of Serbia. The research period covers the years 2018./2022. The study includes a comparative analysis of vineyard areas, grape production and yield, as well as wine imports and exports from the territory of the Republic of Serbia.

Despite Serbia's potential for wine exports, primarily due to its natural resources for grape production and processing, as well as numerous multilateral and bilateral agreements, our country is considered a major wine importer. In terms of imports, the largest quantities are imported from CEFTA countries, primarily from North Macedonia, followed by Montenegro. The existing situation can be changed, but only if the state provides support to small wineries.

Key words: wine market, small wineries, state support

Introduction

At present, Serbia is primarily an importer of wine, although it used to be a significant wine producer for domestic consumption, the needs of the former Yugoslav republics, as well as an exporter of wine. When it comes to wine import in Serbia, the largest amounts are imported from CEFTA countries,primarily from North Macedonia,and Montenegro. When it comes to wine exports, the largest amounts are exported to the market of The

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Russian Federation, as well as to the market of CEFTA countries, primarily to Bosnia and Herzegovina, and Montenegro.

Serbia has great potential for export of produced wine, according to the fact that we do have a large number of multilateral and bilateral agreements which confirms that we have specific level of custom's protection in the trade. The most significant trade agreements for Serbia are with the countries of the Southeast European region (CEFTA), the European Union, the Russian Federation, Belarus, Kazahstan and Turkey.

To utilize the existing potential in wine production, it is necessary to prevent a constant decline in total vineyard areas and establish new vineyards with modern varieties aligned with contemporary production trends. Futhermore, to enter the foreign market, it is necessary to improve the quality of wine production,which,in addition to technology, expertise and skills, also requires quality grapes.

Market of Grape and Wine Producers in Serbia

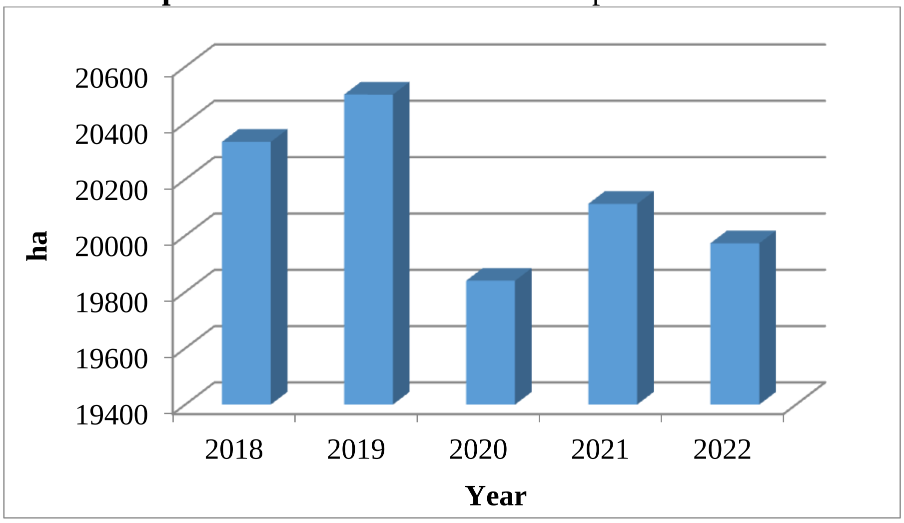
The wine market is influenced by the dynamics of supply and demand .However, it is also dependent on a series of other factors, including production, agro-ecological, climatic, and processing-technical factors, which are conditioned by the level of technical equipment and technological education of participants.Wine is a significant commodity in international trade and has a log tradition in international circulation (Vlahovic et al. 2017). According to Jaksic (2019), the Republic od Serbia is currently classified as a wine-importing country, although it used to be a major wine producer, both for its own population and for the needs of the former Yugoslavia republics, as well as a significant wine exporter. The most amounts of wine are exported to the market of Russian Federation, as well as the market of CEFTA countries, Bosnia and Herzegovina, and Montenegro. When it comes to wine import in Serbia, the most amounts are imported from CEFTA countries, North Macedonia and Montenegro, and when it comes to EU members, the most amounts are imported from Italy and France.

The biggest importer of wine in the group of CEFTA is Republic of Serbia. Wine is imported partly in in bulk and partly in bottles. Some of the domestic wineries mostly import red wine, which is cared and nurtured, and later is filled in the bottles and placed to the market.If we talk about wine import in the bottles red wines dominate, and black wines of different trade marks. The wine export from Serbia may be characterised as modest.The most important foreign trade partner is Bosnia and Herzegovina, where half of wine import is realised. After Bosnia and Herzegovina as the countries which are pointed out by wine export from Serbia is Montenegro,and smaller buyers are Germany, Austria, Croatia (Vlahovic and co 2011)

In Markovic's opinion, 2008 if we want to use potential for grapes producing and processing into wine, which Republic of Serbia owns, it is necessary to stop constant decline of cultivated areas under vines by raising new modern vineyards. Such an occurance would affect to quality raisingin wine production in the future, beside technology, expertise and skills it is necessary to provide quality grapes.

According to Tarailo, Vuksanovic, 2021. one characteristic of grape cultivation in Serbia is that the largest vineyard areas are in the individual ownership sector. These vineyards have an unfavorable age structure and are dominated by extensive cultivation forms, with unfavorable varietes that have low yield capacity and limited mechanization possibilities for implementing agrotechnical measures.In the upcoming vineyard renewal, attention must be given to modernizing the grape varietes, introducing more intensive cultivation forms, and providing conditions for the application of appropriate mechanization in all work phases. Additionally, it is necessary to find long-term solutions for grape and grape product prices. Graph 1 shows the areas under vines in the Republic of Serbia in the period from 2018 to 2022.

Graph 1. Areas under vines in the Republic of Serbia

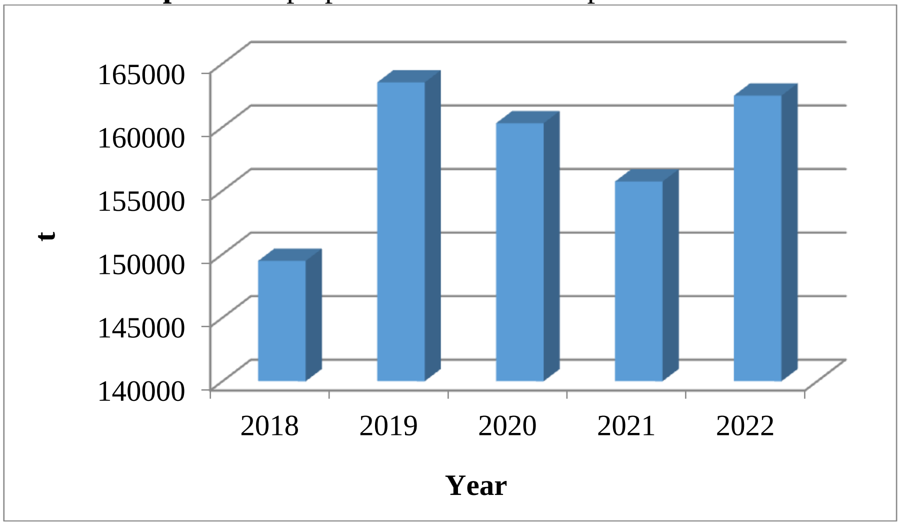


Source: Statistical Office of the Republic of Serbia

Also, it is necessary to solve the issue of prices of grapes and grape products in the long term.

Grapes are the most important product of vine. From total amount of produced grapes in the world 20% is used for eating as fresh and dry grapes, and the rest of 80% is processed to wine, distilled alcoholic drink, jams and juice. The wine is the most important product made of grapes (Radanovic, Markovic, 2015). Graph 2 shows grapes production to period from 2018 to 2020.

Graph 2. Grape production in the Republic of Serbia

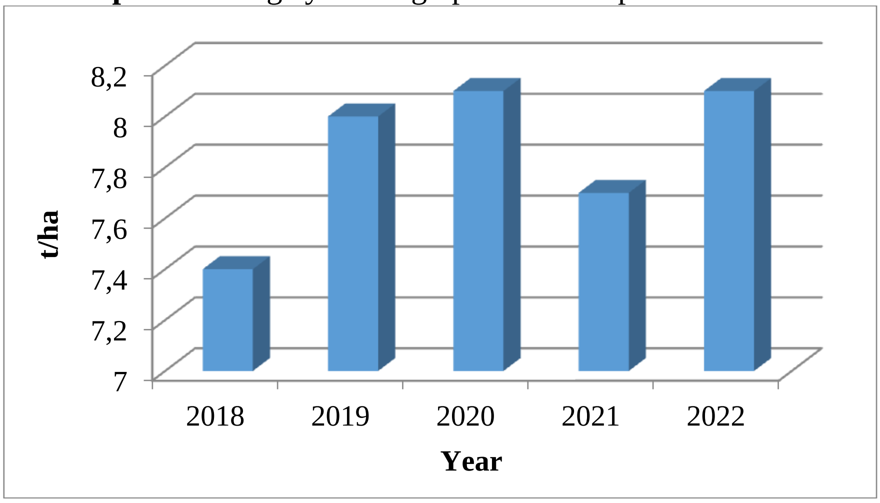


Source: Statistical Office of the Republic of Serbia

So, it is necessary that existing wine amounts of grapes in Serbia enlarge, as well as to be stable, so we could succeed in long term watching, provide our own wine production, which will be over the amounts of wine that we are importing currently from CEFTA countries, as well as from the European Union.

Yield of grapes in observing of five years period in the graph 3 varies, and the smallest yield is recorded in 2018. From 7.4 t/ha, while the same yield can be seen during the period from 2020 to 2022, from 8.1 t/ ha. The achieved yield fluctuates significantly from year to year, depending on climatic conditions and weather circumstances. To increase the existing grape yields, it is necessary to introduce modern vine planting materials that have appropriate resistance to diseases and pests.

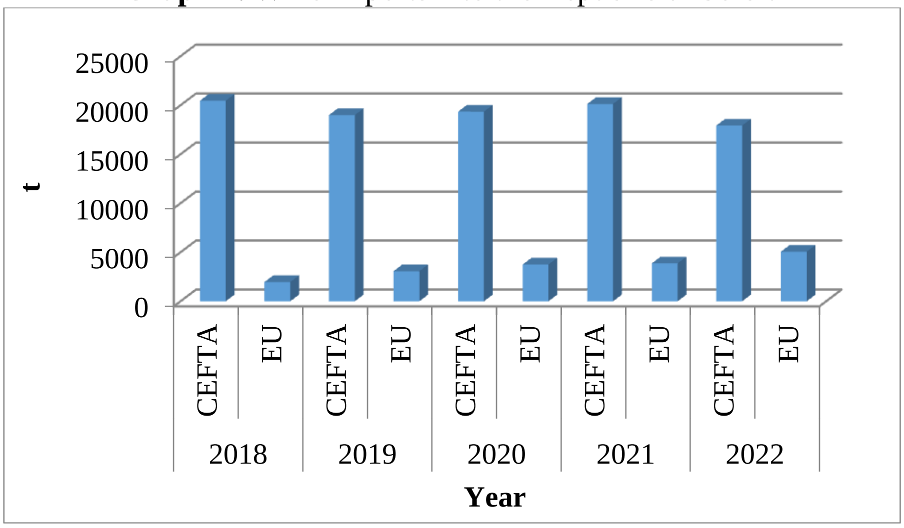
Graph 3. Average yield of grapes in the Republic of Serbia



Source: Statistical Office of the Republic of Serbia

The Republic of Serbia mostly import from CEFTA countries, and on the second place are the countries of the European Union. Relative to observing five years period which is showed in the graph 4 we can see the drop in imported wine amounts, mostly amounts are imported from CEFTA countries during the year 2018, and the largest amounts are imported from the European Union during 2022.

Graph 4. Wine imports into the Republic of Serbia

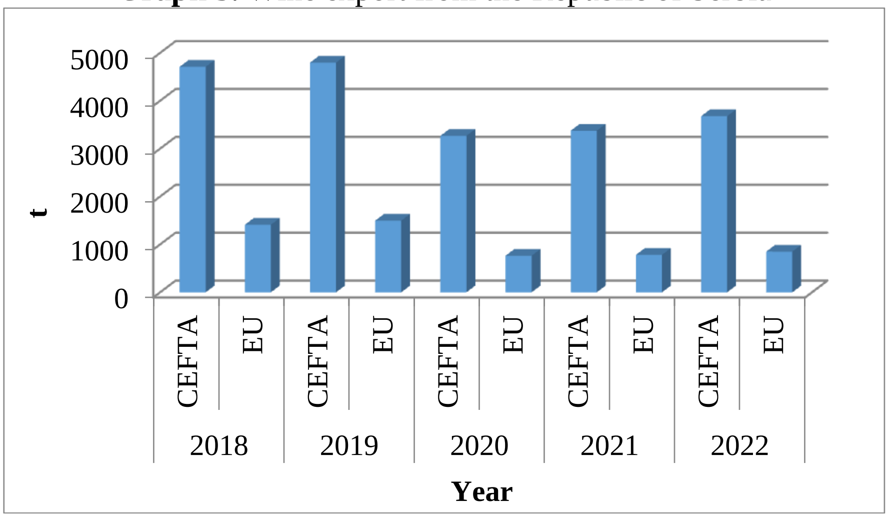


Source: Statistical Office of the Republic of Serbia

The supply of the domestic wine market in Serbia is not sufficient for its own needs, which is why the import of wine is at least twice as large as the export. However, the problem is in the fact that the import is focused to the cheap wines from Northern Macedonia, which is caused by weaker purchasing power of the population as well as ignorance of wine drinking culture, and it is necessery to work on marketing primarily small wineries.

If exorts are obserbed by grouping of countries, it can be seen that the largest quantities are placed to the market of CEFTA countries, and to the European Union. Among CEFTA countries for wine export the most remarkable market is the market of Bosnia and Herzegovina and Montenegro, which are considered relativelly stable. Also, remarkable market for wine export from Serbia is the Russian Federation.

Graph 5. Wine export from the Republic of Serbia



Source: Statistical Office of the Republic of Serbia

Related to the observing period of five years, which is shown on the graph 5 it is noticed the drop in the amounts of wine that we export, as well to the CEFTA countries as to the countries of The European Unioun. Related to The Programme development of winemaking and viticulture of The Rebublic of Serbia for period 2021 to 2031. It is necessary to strengthen import control, lomit unfair import,ensure a quality product on the wine market and reduce the space for gray wine trade. Serbia has been achieving a negative foreign trade balance, so it is so necessery to work on the utilization of existing resources in the production of wine.Therefore, in order to increase the export of wine to the markets of the countries in the region, we have to increase the existing wine production in such a way that we can, first of all, satisfy the needs of the domestic market, and this implis an increase in the area under vines, introducing varieties that guarantee high yields and the appropriate level of resistence to diseases and pests.

Government support for the viticulture and winemaking sector in the Republic of Serbia

Serbia belongs to a group of countries where viticulture has a long history but has not received sufficient attention in recent decades.There have been various factors that have impacted vine cultivation and wine production, particularly events during the 90’s of 20th century. Serbia has great potential for producing quality, specia, and tradition wines. The strategy of development in wine sector is refered to enlarging of existing areas where grapes should be produced for quality wines with the indicated geographical origin (Erdelji, Lajko, 2015)

Ministry of Agriculture, Forestry and Water Management provide support to registered agricultural households throughout the production phases, including the procurement of seed material, grape production, wine production, and the promotion of geographical indications.The solution lies in increasing vineyard areas and utuilizing grapes produced in Serbia for wine production.However, to achieve this effect, adequate capital and additional financial resources are necessery, considering the long-term nature of grape cultivation, where the investment period lasts between five and six years.

In Serbia small wineries are predominant, and they face challenges in marketing their products both domestically and internationally .It is necessary for the government to distinguish between small and large wine producers, as their financial structures and expectations differ. Specifically, small wineries have limited opportunities for product placement on the market, necessitating targeted support and marketing initiatives to help them access domestic and international markets, which represents one of the risks for enlarging capacity of small vineries, and the entrance to wine industry .Small vineries have limited opportunities for product placement on the market due to lack of budget funds .One of the key solutions for grape and wine producers may be education and motivation to form cooperative systems. These cooperatives would employ experts in grape and wine production as well as professionals in product placement and marketing for the producers. According to *Pivac* 2012. Wine tourism benefits wineries by increasing sales. By distributing wine at the winery, visitors are encouraged to make purchases directly at lower prices instead of going through distributors and retailers. The development of wine tourism can help establish new connections with wine retailers as visitors may seek out the wine from their local sellers upon their return.

Conclusion and recommendation

The grape production sector in the Republic of Serbia is highly specific, primarily due to the large number of grape producers who cultivate their vineyards on small areas. On the other hand, the majority of wine production comes from small family farms. Small vineyard areas and wine producer are often unable to supply the Serbian market with domestic wine, resulting in a necessary import of wine that is at least twice as high as exports.

It is necessary to change the existing situation , which involves increasing the vineyard area while adhering to quality standards , leading to an increase in wine production for both the domestic market and exports.

To achieve these affects, it is necessary for small wineries to form cooperatives where professional personnel can be employed for both the high-quality wine production process and the marketing and placement of the produced wine.

So, it is necessary to change the existing state, primarily when it comes to wine import, and that implies to increase control at import itself, as we could protect domestic wine producers in Serbia.The problem is also in the fact that there is no suitable educational staff, who would educate winegrowers and winemakers about modern trends in wine production and wine placement.

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Turnover and Consumption of Cucumber in Serbia

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Abstract

The aim of the research was to analyze the production, trade and consumption of cucumbers in Serbia in the period 2013-2022 using a quantitative research method. The results show that in relation to import and export, cucumber production in Serbia is declining. A surplus of over 6,191.00 tonnes, i.e. 1,083,000.00 dollars, was achieved in foreign trade in this vegetable, with a large fluctuation in the shortage. The self-sufficiency of these vegetables in Serbia was constantly growing and was on average over 100%, while the consumption of these vegetables showed a continuous decline in the same period with an average of 5.77 per capita. The largest importer of cucumbers from Serbia is Albania with an average import of 4,057 tons, while the most important export destination of this vegetable is Germany with an average export of 9,137 tons. The research is significant because it provides a solid basis for future rational planning and decisions in Serbian vegetable production.

Key words: cucumber, turnover, consumption, foreign trade exchange

Introduction

Cucumber is an important vegetable plant species and Serbia has good agroecological conditions for its cultivation. Cucumber is a plant species of subtropical and tropical climates (Popović and Takač, 2018), but today it has a wide area of distribution. According to Adeoye and Balogun (2016),

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cucumber is a significant source of antioxidant nutrients (vitamin C, beta carotene, manganese). As Marković (2010) points out, in addition to being used for food purposes, cucumber is also an important raw material in other industries (pharmaceutical, cosmetic).

In the world, according to the available data, the production of cucumber in 2021 was at the level of 93,528,796 tons, while the area under this vegetable in the same year was 2,172,193 hectares. China is one of the world's largest producers of cucumbers, with a production of over 75.5 tons, which accounts for over 80% of the world's total production. Far behind it in second and third place are Turkey and the Russian Federation with production of 1,890,160 tons and 1,648,639 tons, respectively (www.faostat.org). When it comes to foreign trade parameters of this vegetable, i.e. import and export, we can conclude that the situation is a little different. Namely, the largest importer of cucumbers in the world last year was the USA with 1,188,366 tons imported, while the largest exporter was Spain with 958,443 tons (www.trademap.org). In the global context, the production and import and export of cucumbers in Serbia is a very small part.

The aim of the work is to analyze the production, trade and consumption of cucumbers in Serbia in the past ten-year period (2013-2022). For this purpose, the works of individual authors who in the previous period dealt with the forecasting of the production of some vegetable species were analyzed (Lazić, 2014; Ivanišević, 2015; Hossain and Abdulla, 2016; Puškarić and Vlahović, 2018; Nedeljković and Vujić, 2020; Nedeljković , 2021; Nedeljković, 2022; Nedeljković et al., 2023).

In their research, Brankov and Matkovski (2022) deal with the potential shortage of food in the Balkans and on this occasion examine the consumption and self-sufficiency of certain groups of plant and livestock products in some of the countries of the Western Balkans. Apart from the previously mentioned authors, other authors also dealt with the analysis of self-sufficiency in food (Slaboch and Kotyza, 2016; Kubala and Stanuch, 2021).

Some authors in their research emphasized the comparative analysis of export and import prices of these vegetables (Stojanović, 2011; Vlahović and Puškarić, 2012; Puškarić, 2012; Vlahović, 2015; Workman, 2017).

Methodology and data sources

Ten-year data (2013-2022) of production and foreign trade parameters of fresh cucumbers in Serbia (area, production, yield, import and export) were analyzed, which were taken from the available databases of the Statistical Office of the Republic of Serbia (SORS), as well as the FAOStat database. and the International Trade Center ITC (International Trade Center). Also, for the purposes of the research, the per capita consumption of the analyzed vegetable species was calculated, as well as the degree of self-sufficiency according to the formulas of the applied FAO methodology. (degree of self-sufficiency = production/production + import – export * 100; consumption per capita = production + import – export/estimated population). Standard indicators of descriptive statistics (average, interval of variation, standard deviation (SD) and coefficient of variation (cv) were used to obtain the results. It should be noted that when obtaining the results, the occurrence of stock was not taken into account.

In the continuation of the paper, the results are presented in tabular and graphical form.

Research results and discussions

The average area of cucumber in the analyzed period in Serbia was slightly more than 3,503 ha. The movement of areas under this vegetable was relatively stable with a recorded maximum of 4,271 ha. Cucumber production in the same period showed greater instability, and its average was at the level of over 44,549 tons. Most cucumbers were produced at the beginning of the analyzed period (63,687 tons). The most stable trend was the cucumber yield (cv=15.04%), and its average value was 12.48 t/ha. (table 1).

Table 1. Dynamics of cucumber production indicators in Serbia (2013-2022)

Indicators	Average	Variation interval		Coeff. of variation (%)
		Min.	Max.	
Area (ha)	3.503,70	2.769,0	4.271,0	17,56
Production (t)	44.549,90	29.177,0	63.687,0	30,07
Yield (t/ha)	12,48	9,80	15,70	15,04

Source: Processing by the author according to the data of the SORS

Foreign trade indicators (import and export) of cucumber show relatively high instability in the past ten-year period. Namely, for the observed ten years, a foreign trade surplus was realized, which amounted to an average of over 6,191 tons, but its great instability measured by the coefficient of variation (cv=90.71) was also observed. The highest recorded surplus was in 2021 and amounted to 16,295 tons. It is interesting that the lowest production of cucumber in the observed period in Serbia was recorded then, while at the highest recorded production, which was at the beginning of the past ten-year period, the smallest import of this vegetable crop was realized. (table 2) Chart 1 gives us a visual representation of the production and quantitative import and export of cucumbers.

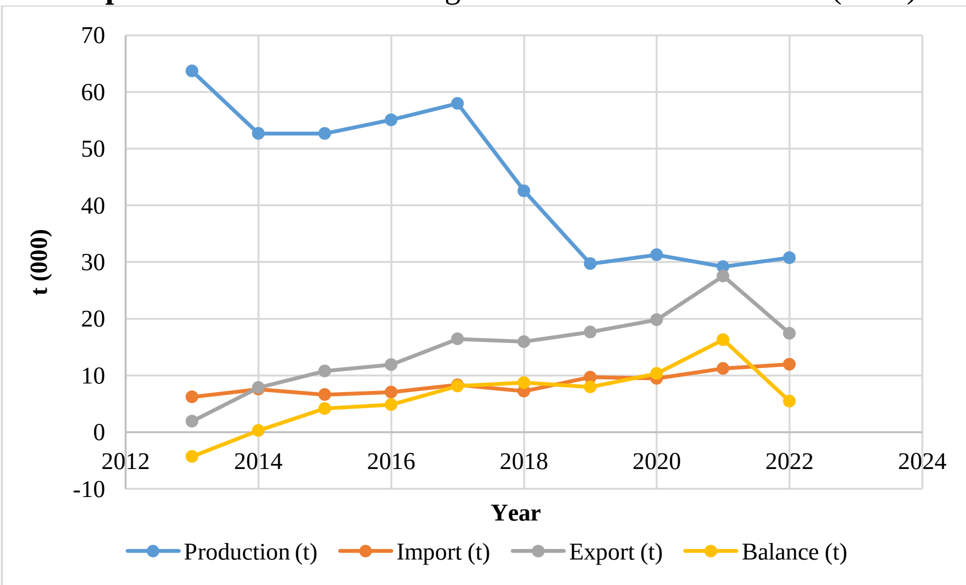
When it comes to the value presentation of foreign trade indicators of cucumbers in Serbia from table 2, we can see that there was a surplus in the foreign trade exchange of this vegetable for the given analyzed period, and it was an average of 1,083,000 dollars. The variation of the achieved balance was huge and ranged from the deficit (-3,349,000 dollars) that was realized in 2013 to the maximum surplus (5,409,000 dollars) that was recorded in 2021. On graph 2, we can follow the movement from year to year in the value ($) of cucumber imports and exports.

Table 2. Dynamics of foreign trade indicators of cucumber in Serbia (2013-2022)

Indicators	Average	Variation interval		Coeff. of variation (%)
		Min.	Max.	
Import (t)	8.536,90	6.219,00	11.960,00	23,11
Export (t)	14.728,50	1.928,00	27.519,00	47,70
Balance (t)	6.191,60	-4.291,00	16.295,00	90,71
Import ($)	6.587.200,00	4.256.000,00	11.617.000,00	41,26
Export ($)	7.670.200,00	1.310.000,00	16.188.000,00	59,91
Balance ($)	1.083.000,00	-3.349.000,00	5.409.000,00	268,20

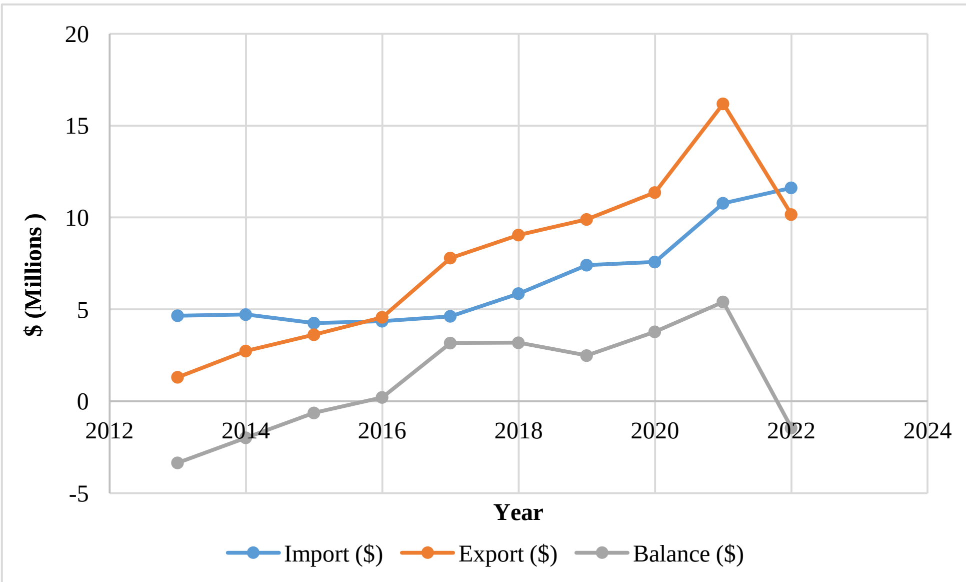
Source: Processing by the author according to ITC data

Graph 1. Production and foreign trade balance of cucumber (000 t)



Source: The chart was created by the authors

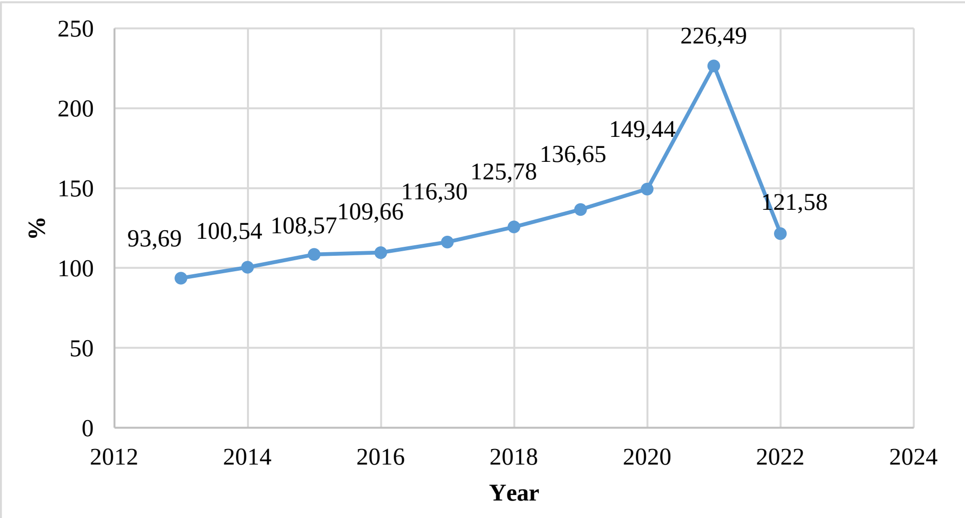
Graph 2. Cucumber foreign trade balance ($)



Source: The chart was created by the authors

Food self-sufficiency is one of the most commonly used indicators. Serbia is self-sufficient in the production of vegetables, which is indicated by the fact that the average degree of self-sufficiency of these vegetables in the period 2013-2022 was over 100%, that is, about 129%. Self-sufficiency shows a constant growth, especially pronounced in 2021, by as much as 226.49%. (graph 3) The obtained data largely agree with the results of the research conducted in the past period by Brankov and Matkovski (2022). Namely, in their work, they show that the measured degree of self-sufficiency of vegetable products, and especially of certain agricultural products, is over 100% and that Serbia dominates in the self-sufficiency of these products compared to most countries of the Western Balkans.

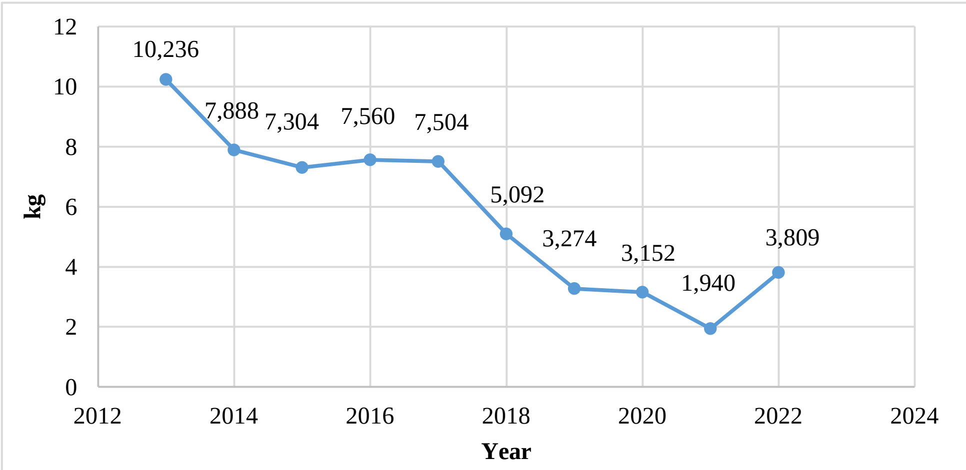
Graph 3. Cucumber Self-sufficiency (%)



Source: The chart was created by the authors

The average recorded consumption in the analyzed period was 5.77 kg/h. and in contrast to self-sufficiency in production, the consumption of cucumbers throughout the analyzed period shows a constant decline, the maximum of which is in 2021, while in the last year of the analyzed period there is an increase in consumption at the level of 3.8 kg/h. (graph 4) It should be noted that cucumber is sensitive to price movements, that is, that a higher price leads to a change in the behavior of customers, that is, that cucumber is easily replaced by some other similar and available vegetable, either for consumption or for industrial use.

Graph 4. Consumption per capita (kg)



Source: The chart was created by the authors

The data from the following table 3 show that the largest import of cucumbers was recorded from Albania, with an average of 4,057 tons for the ten-year period (2013-2022), while in the same period, the most cucumbers were exported to Germany, with an average of 9,137 tons for the observed period.

Table 3. The most important importers and exporters of cucumber

Countries	Average (t)	Variation interval		Coefficient of. variation (%)
		Min.	Max.	
Import				
Albania	4.057,60	308,00	6.860,00	61,36
N. Macedonia	1.989,00	192,00	5.478,00	95,94
Greece	848,20	350,00	1.669,00	51,79
Spain	709,60	364,00	1.206,00	33,70
Italia	270,20	88,00	652,00	66,12
Export				
Germany	9.137,00	336,0	19.435,0	56,15
Austria	1.448,11	22,0	3.781,0	89,78
Croatia	1.242,40	80,0	2.738,0	84,29
Hungary	860,38	43,0	2.005,0	86,39
BiH	533,10	127,0	1.553,0	83,36

Source: Processing by the author according to ITC data

A large fluctuation was reported in both imports from the mentioned countries and exports.

Conclusion

Cucumber is an important vegetable species in Serbia, on the basis of which a surplus in foreign trade was realized in the past ten-year period (2013-2022). The average recorded balance in the foreign trade exchange was 6,191.60 tons, or 1,083,000.00 dollars, with large variations in its movement. Self-sufficiency was constantly growing until 2021 in relation to cucumber consumption, where a continuous decline was recorded and whose average value for the analyzed period was 5.77 kg/h. Cucumbers were mostly imported from Albania, an average of 4,057.60 tons for the period 2013-2022. year, and the country to which Serbia exported the most was Germany. In the following research, the additional impact on the foreign trade movements of these vegetables in Serbia should be examined, as well as the directions of action that would lead to rational production in the future should be determined.

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Sale of Food and Beverages of Small Domestic Producers During the Period of COVID-19

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Abstract

The subject of research in this paper is the analysis of the possibility of selling agricultural products of small producers and improving their business in a specific way... by direct sales in catering establishments.

The goal of the research is how, in the specific circumstances caused by Covid-19, to implement the direct sale of produced food and beverages of small domestic producers.

The methods used during the creation of the work were direct communication and observation of the situation in real time, in the sense of determining the real needs and demand for certain products on the market.

Data sources were mostly obtained via the Internet, given the impossibility of concrete contact.

The results of the research are reflected in the completely new circumstances of the distribution of food and beverages to end consumers. For the purposes of this work, field research was also conducted.

Key words: food and drink, catering facilities, domestic products, Covid-19

Introduction

Serbia is a country with a long-standing tradition of producing domestic products from authentic ethnic-geographical areas. It has been building its quality and innovation for centuries. During the past phases of transitions that took place in these areas years ago, enthusiasm was the main factor in the survival of society and the economy. Some of the obstacles encountered by small and medium-sized enterprises in Serbia, as well as agricultural farms, are opportunities, time and resources for effective marketing of products on the market. In this, the company Serbeat d.o.o. which consists

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of a team with many years of experience in the field of economics, market research, marketing, sales, training and education, wants to help.

The concept of "SMART" goals is already known by that short name, and it has been used in various forms for several decades. It stands for Specific, Measurable, Attainable, Relevant and Time-bound. How to use SMART goals to define key performance indicators will be discussed through a practical demonstration, but here is a brief explanation:

- ✓ **Specific.** Be specific about what you want to achieve.
- ✓ **Measurable**. Use measurable indicators to help track project performance.
- ✓ **Attainable**. Goals should be realistic. It's nice to dream about towers and cities, but you need to set achievable control points.
- ✓ **Relevant**. Are the indicators related to the project? If you have identified the expected goals, it will be easier to determine if the key performance indicators are relevant.
- ✓ **Time-bound**. Set a time limit. Specify a start and end so you can set baselines and control points. With this set interval you can, for example, identify seasonal changes, migrations, product releases and more.

Given the new conditions due to the Covid-19 virus, newspapers were introduced to the method of direct or, as we also call it, traditional sales, given the impossibility of constant direct contact with clients and producers. Therefore, on the example of a company that brings together producers and buyers on a unique platform called "Serbeat", we will see a concrete way of selling, which until the new conditions was direct selling, but now we can still call it distance selling. From the social structure of students, analysis indicates that significant changes have occurred.

The subject of research in this paper is the analysis of the possibility of selling agricultural products of small producers and improving their business in a specific way... by direct sales in catering facilities and in an immediate way - consumption by visitors (guests), which should cause that the product is purchased by the consumer when leaving the facility. In this way, direct sales are envisioned by direct offers from small producers through a new way of "advertising" products from different areas of agricultural production.

In essence, the entire business of small agricultural producers is conceived through the unification of the presentation of those products in a relaxed and immediate atmosphere, where the ultimate goal is direct sales, and that is the subject of this work.

Until now, there was no such way of selling, so the specific idea came from a different angle of looking at the direct sale of products, the advertising campaign of small producers, who are often not known, which does not reduce the quality of their production and product offer, and from the personal experience of the author of this work - how to combine the beautiful and the useful, and in this case, going out with friends and having a good time with a quality offer and consumption of domestic products. The idea arose from cooperation with small producers and the will to have a good time and quality offer that can be found in our catering facilities, and also to include quality products in the food and drink offered by catering facilities.

Research results and discussions

The work is based on empirical research, with practical support. Each segment of this work is first of all practically presented, referring to the current situation and the constant struggle to carry out sales in the new circumstances of direct sales conditioned by Kovid 19. After the theoretical definition, concrete phenomena, conditions and causes of the mentioned phenomena are described using the method of description.

For the purposes of this work, field research was also conducted. This research covers over 20 small agricultural producers who sell directly through hospitality establishments. This sales perspective is brand new and still under research. It has become interesting to observe and improve this type of sales and to push the boundaries of the effectiveness of the approach to consumers.

The paper will explain the demand for food under normal conditions, more precisely before the Coronavirus pandemic. Next, we will highlight the changes in the demand for food during the pandemic.

In addition, it is essential to point out the demand for non-food products, which are necessary when purchasing food.

We will highlight the implications for supply chains and changes in customer behavior in individual markets. In order to adapt to the new operating conditions in the age of the pandemic, innovative approaches in food supply, changes in supply chains and their long-term consequences will be explained.

The paper will explain the formation of food prices under normal circumstances and during the pandemic. We will remind you what the word regulation means and how state regulation affects supply, demand and price formation in the age of a pandemic (Cutvarić & Ivančević, 2005).

We will remind you of the measures that were introduced in the EU countries and America due to the pandemic, then what kind of measures were introduced in the countries of the Western Balkans, and then in our country - in Serbia. We will list chronologically the differences in measures by content and time of introduction.

We cannot leave out the distribution of products to end consumers. So we will explain how a new workplace came to life, from which both those who organized the distribution chain and those who performed it, and still perform it, made a nice additional income. Especially during the curfew due to the Coronavirus pandemic, which was introduced in order to reduce the spread of infection and therefore mortality, it is the delivery men and couriers, who had special movement permits for this type of work, that gain importance.

And finally, we will get acquainted with the newly created way of functioning of catering facilities in terms of looking for food and in general, opportunities for work.

Demand for food during the Covid-19 pandemic

For the first time, people started talking about Covid in our area in November 2019, when the first closure of cities in Italy began. Back then, it was not expected that our lives would change so much in all aspects, including the demand for food. When the Coronavirus pandemic began, called - Kovid 19, there was a complete change in the way of life and functioning in all aspects of human life around the globe. It can be said that the world has stopped... There are also changes in the demand for food. So that the mass purchase of flour, yeast, toilet paper, masks and disinfectants did not mark March and April 2020, only in Serbia, but was noticed all over the world, from Australia to America.

Implications for supply chains

Up to a hundred suppliers often participate in the modern multi-level supply chain. Unforeseen weaknesses within these supply chains cost businesses millions of euros every year. It was during the corona pandemic that logistics became the central management unit of all companies and industries.

For successful risk management, it is recommended to target "known risks" on one side and "unknown" on the other. By "known risks" are meant threats such as late deliveries, material cost changes or supplier disruptions. In the case of proper examination and knowledge of the market, they can not only be predicted, but also systematically categorized and clear recommendations for action should they appear in advance.

In both cases, a framework for risk management should be created. It calculates the probability of occurrence as well as the expected consequences for the company and the remaining part of the supply chain. The first contribution here is a simple traffic light system from low to high risk with typical scenarios and corresponding recommendations for action.

"Unknown risks," in contrast, describe events that are difficult to predict, such as natural disasters, unexpected political unrest, or pandemics such as COVID-19. Supply Chain Risk Management (risk management in the supply chain) is usually divided into the phases of identification, analysis, management and monitoring for both scenarios. Ideally, risks should be identified and documented at each step of the supply chain. First of all, one must train and sensitize one's own staff. Through employee training, job standardization and the development of the structure of supervision, analysis and reporting, a culture of risk awareness is created in the company. Thus, among other things, employees should receive a positive response if they speak openly about possible risks in the supply chain. Responsibilities and expectations should also be clearly discussed. In this way, all participants become aware of the consequences, as well as the limits of risk tolerance within the company - and possible risks quickly find ways to solve them. When it comes to our country, according to the European Innovation Index in 2019, we were a country with a medium degree of innovation, although with a continuous upward trend since 2010. The main carriers of innovation processes in our country are individual innovators, company investments and online sales, while currently there is a lack of strong research ecosystems and financial support for innovation development, which we expect to be improved by additional fiscal incentives for the research and development sector.

Online sales and home delivery have "taken life" the most. These are also the biggest innovations in the way of supplying customers with food, drinks and other necessities. During the curfew, when movement was completely prohibited for a certain period of time, and all in order to reduce the risk of the spread of the virus, the only way of supply was precisely the courier services and deliverymen who supplied with their vehicles, i.e. delivered the ordered food, drinks and other offers from the assortment that could be searched via the Internet. Active management minimizes risk (Grozdanović & Stojiljković, 2013).

Changes in customer behavior in certain markets

When we talk about our country, it is very important to emphasize our way of life and the peculiar mentality of consumers, which directly affects the market.

Serbia is a country known for its people who love going out, delicious food and drinks. Going out is a daily habit of the population in our country. Depending on the age, different places are visited, but catering facilities are always at the forefront: restaurants, cafes, clubs, rafts.

Whether it's family, business or social outings - one thing is certain...food and drinks are an indispensable part of every outing. Or at least one of those two.

With the new situation in the behavior of end consumers, who are used to having normal supply and movement, there is a change in the behavior of buyers, i.e. end consumers.

Buyer behavior depended primarily on the market. Some countries have limited the amount of purchases of certain products, so that everyone can make their purchases. Mostly the members of the European Union introduced such restrictions, while in the territories of the Western Balkan countries, the possibility remains that everyone can buy as much as they want and find at a given moment of purchase.

While one part of the population frantically purchased and made enormous stocks of various products, one part went to the villages - there was also a part of the population that, as in previous critical situations, indulged in the way of "living in the moment".

Extreme situations, such as a pandemic, lead to extreme measures and changes in people's behavior. In this paper, the emphasis is on the change in customer behavior. It is interesting to note that regardless of procurement of basic foodstuffs, such as: flour, sugar, oil, bread, milk, yeast, the demand for alcohol increased.

Small producers of alcoholic beverages, primarily brandy and wine, sold five times more of their products than before the pandemic. The reason for the increase in sales is not the lack of supply of sales or catering facilities, but the inability to consume at times when the need arises. To simplify the explanation - with the introduction of new measures, the closure of catering facilities and the inability to move are the main causes of drinking and food consumption exclusively at home.

Demand for non-food products and the impact on food demand

Citizens' demand for surgical masks and disinfectants such as asepsol, alcohol, gels and hydrogen exceeded the ability of pharmacies to obtain sufficient quantities of everything - this is the answer that consumers received in drugstores and pharmacies. Masks were absolutely nowhere to be found, and the shortage was on a global scale.

In stores all over Serbia, the demand became huge and the goods were quickly disappearing. The shelves in these facilities, which normally contain masks, asepsol, antibacterial wet wipes, gels and alcohol, were devastated.

Masks have stopped reaching the shelves since the beginning of 2020, disinfectants were successfully offered all the time, but within two hours everything would be sold out (https://www.bbc.com/serbian/lat/srbija-52002874).

The prices of all disinfectants, despite the huge demand, were not allowed to change. At least that's how it should have been by law. In practice, it happened that a surgical mask whose price was 10 dinars reached the amount of 250 dinars. Later it was sanctioned, but the first moments of purchasing disinfectants and protective agents were extremely expensive for customers.

In the retail chains of food products and consumer goods, there was enough in stock and officially there was no need for citizens to buy larger quantities. The condition for entering the sales premises was, first of all, appropriate protective measures, so there was a wait in line, because a certain number of customers could be in the premises, wearing a protective mask and gloves. In such circumstances, consumers bought in large quantities, both for panic reasons and for practical reasons - so that they would not stand in the same lines again in a few days and go through the same procedures that required protective measures during the pandemic. There was a lack of flour, oil, rice, pasta, certain types of canned food, and hygiene products. Employees in sales facilities did not remember those huge queues and such a situation in general.

Changes in supply chains

KPIs show you the success or failure of specific campaigns or business tactics so you can continually improve and build on those ideas. In other words, key performance indicators are an accurate and unbiased measure of success.

Key performance indicators of small businesses, such as growth rate and gross profit rate, are reliable indicators of a company's health. They got a clear insight, precisely defined those and all other indicators you want to measure.

Adapting business conditions to a completely new way of functioning in all spheres of life, and therefore also in direct sales, is the task of current and future generations. It is no longer the same meaning of so-called traditional selling, which was actually direct selling all along.

Adapting to the new conditions of the way of living and doing business, yet maintaining uniqueness and originality while constantly following trends and realizing plans is actually a goal that we got completely unplanned with the arrival of KOVID 19.

Constant change and adaptation to it is the ultimate message for the new age in which we have begun to function.

Specifics of searching for food in catering establishments

In 2019, we came up with the idea to offer something completely different and simple to supply during the outings - domestic products of small producers, which are not known to consumers. In this way, while relaxing in the circle of friends, the consumption of new products, which already exist on the market, but whose quality is significantly better, begins. The reason for the better quality is precisely the production at the household level, so what is made in larger quantities goes on sale. The goal was to connect the beautiful and the useful - going out and selling local products of small producers.

As a country, we are known to like to spend our free time going out with family or friends, so it was very justified to enjoy something homemade, tasty and affordable when visiting restaurants.

Until the state of emergency was declared on Sunday, March 15, 2020 - because of the coronavirus, dating was functioning throughout the country.

The idea of direct sales of domestic products has come to life and is well implemented.

The problem arose in sales in the hospitality industry with the introduction of measures due to the pandemic and the facilities were closed. It was only through distribution, more precisely online sales, that catering establishments could continue direct sales of food and beverages.

This is how new companies are opened that deal exclusively with delivery, which is done by people with their vehicles or bicycles. They had special permits to move during the curfew and they supplied their fellow citizens with everything they ordered. A good business developed with good earnings, and the sales did not stop.

With the opening of catering establishments, this practice continued - home delivery, but also direct sales in establishments (restaurants, cafes, night clubs). So, one thing is certain - food sales simply have to work from an even simpler explanation - we all have to eat.

Conclusion

The entire business of small agricultural producers is conceived through the unification of the presentation of those products in a relaxed and immediate atmosphere, where the ultimate goal is direct sales.

The increased demand for food was primarily due to the fear of a possible shortage of basic foodstuffs, so this created an apparent higher demand for food. In the first weeks, the shelves were filled and emptied too quickly, so it seemed that at certain moments the supply did not meet the demand for food. And the reason, in fact, was state regulation regarding the behavior of fellow citizens due to the Coronavirus pandemic.

Over time, the apparent increased demand calmed down and matched the insufficient supply of food on the market.

Imperceptibly, like the coronavirus, the prices of certain foods, goods and services have risen in Serbia in the previous year during the pandemic. Gasoline, oil, fruits and vegetables, electricity, utilities, property tax, TV subscription - these are just some of the items for which we have to allocate more money than before, according to official data, as well as data from the consumer protection association. In the age of the pandemic, the only thing left for us is to adapt and find a way to continue functioning in the way that suits us best in the new circumstances.

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Current Trends in Apple Production and Trade in Serbia and the World[50]

Bojan DIMITRIJEVIĆ[51], Branka BULATOVIĆ[52],
Vladimir ZDRAVKOVIĆ[53]

Abstract

The increase in the area of apple orchards in the world and in Serbia caused a large offer of this fruit on the market and increased competitiveness. In order to better position themselves in the market, producers are forced to modernise their farms.

Therefore, the aim of this paper was to analyse the current situation of production and trade of apples in Serbia and the world and point out the current trends and possibilities of applying modern technical and technological achievements brought by the 4[th] industrial revolution.

The paper used data from the Statistical Office of the Republic of Serbia and the Food and Agriculture Organisation, publications dealing with apple production and trade, as well as literature on the achievements of the Industrial Revolution 4.0. In doing so, the method of analysis, synthesis, description, induction and interview was used. The analysis covers the period from 2011 to 2021.

Key words: Agriculture 4.0., Apple, Information technologies

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Introduction

The apple is the most important fruit species in a temperate climate in terms of production volume. About 85,610,000 tonnes are produced annually worldwide, which places apples second in the group of fruits in terms of production volume, just after bananas (Magazin et al., 2022). In terms of the use value of fruit when fresh, the apple is in first place. It is used as a table fruit all year round, while the period of use of other fruits, with the exception of stone fruits (walnuts, hazelnuts and almonds), is much shorter (Šoškić, 2011). In addition to fresh consumption, apple fruits are also used for various forms of processing, but from an economic point of view, it is the apple produced and sold for fresh consumption that is most important.

Good results in the production of apples, reflected in high and stable yields, good adaptation of apples to different climates, the possibility of long post-harvest storage, safe placement and high economic profit, have made apples a welcome fruit species in the fields of agricultural producers all over the world. The development of modern refrigerators for fruit storage, as well as the efficient transportation of fruit, has made it possible to sell apples to distant markets. All this has contributed to increased competitiveness, reflected in low prices, high quality, appropriate packaging, satisfactory appearance of the apple fruit itself and good marketing.

In order to meet the high demands of customers and to withstand competition, agricultural producers have ushered in a new era in agriculture based on the introduction of information and communication technologies in both the production and sale of agricultural products. This era in agriculture marks the fourth agricultural revolution, known as Agriculture 4.0 or smart agriculture. It is based on the use of digital technologies and is moving towards smarter, more efficient and environmentally friendly agriculture. Besides the introduction of new equipment and technologies in production, the true potential of Agriculture 4.0 lies in the ability to collect, use and share data remotely (Javaid et al., 2022).

Data sources and research methods

The paper uses data from the Statistical Office of the Republic of Serbia (SORS) and the Food and Agriculture Organisation (FAO), as well as publications dealing with apple production and trade in the Republic of

Serbia and the world, and literature dealing with the industrial achievements of Revolution 4.0. and its applications in the field of agriculture, especially in the production and trade of apples. The method of analysis, synthesis, description, induction and interview was used. The analysis covers the period from 2011 to 2021.

Leading apple producers in the world

According to FAO official data, the average total volume of apple production in the world from 2011 to 2021 was about 84,676,724.18 tonnes, with a growth rate of 1.91%. China accounts for the largest production with a total of 40,680,695.45 tonnes, i.e. 48.04% of the total world production (Table 1).

Table 1. Leading apple producers in the world,
in the period from 2011 to 2021 (average)

Rank	Country	Area harvested (ha)	Production quantity (t)	Yield (t/ha)
1.	China	2,136,010.0	40,680,695.5	19.0
2.	USA	126,896.1	4,809,278.3	37.9
3.	Turkey	172,272.7	3,249,469.7	18.9
4.	Poland	174,382.2	3,233,453.5	18.5
5.	Iran	160,394.1	2,483,670.1	15.5
6.	India	306,276.4	2,378,189.1	7.8
7.	Italy	54,951.1	2,308,040.0	42.0
8.	France	47,417.6	1,712,653.9	36.1
9.	Russia	195,323.2	1,697,500.0	8.7
10.	Chile	34,884.9	1,655,888.6	47.5
35.	Serbia	25,320.8	407,073.3	16.1

Source: This table was created by the authors on the basis of data published by FAO - Food and Agriculture Organization, 2023.

The leading apple producers in Europe are Poland (3,233,453.54 tonnes), Italy (2,308,039.98 tonnes) and France (1,712,653.89 tonnes). The biggest jump in apple production was recorded by Russia, which doubled its production in the period from 2011 to 2021, significantly reducing its dependence on apple imports. This trend is unfavourable for Serbia, as the Russian market has been its main export area for many years. The highest productivity in apple production is achieved by Chile (47.5 t/ha). Serbia ranks 35th in the world in total apple production.

Apple production in Serbia

According to SORS data, in 2023 apples rank second in terms of area represented, just behind plums, which traditionally rank first. In 2022, the total area under apples in Serbia was 27,253 ha. As for the regional distribution of apple trees in Serbia, it can be stated that the region "Serbia - South" is the most covered with native apple orchards (16,223.6 ha) and at the same time has the highest production volume, while the highest yield is in the region "Vojvodina" (25.5 t/ha) (Table 2).

Table 2. Harvested area, production quantity and average yield of apples by region in the period from 2018 to 2020 (average)

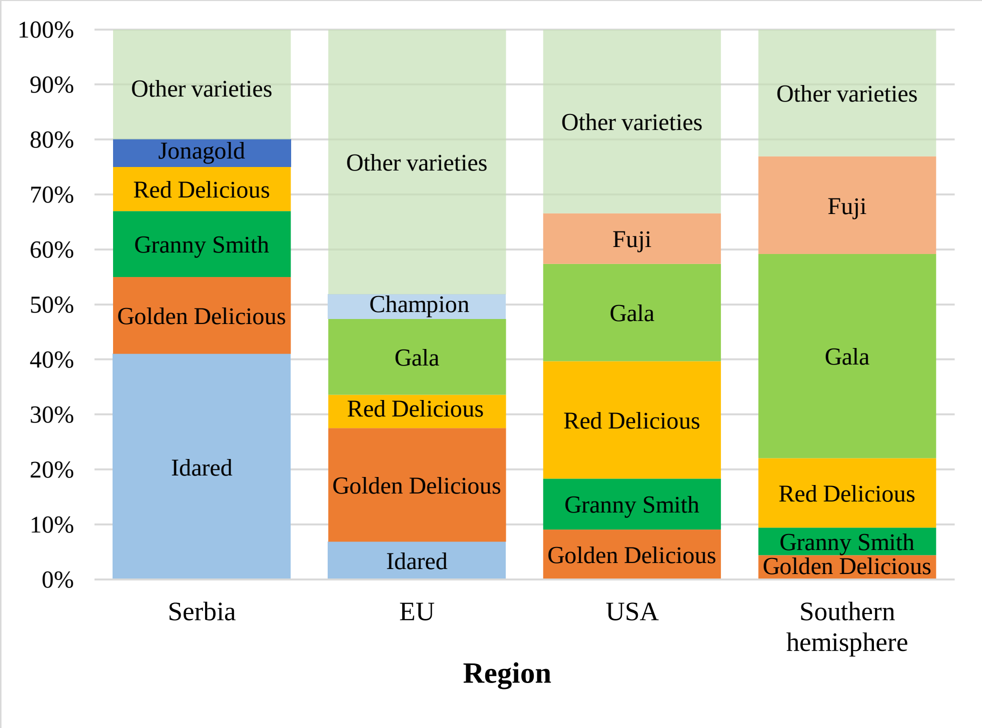
Region	Area harvested (ha)	Production quantity (t)	Yield (t/ha)
Republic of Serbia	26,122.0	483,186.0	18.5
Serbia - North	9,898.3	222,616.3	22.5
Belgrade region	2,416.3	31,562.0	13.0
Region of Vojvodina	7,482.0	191,054.3	25.5
Serbia - south	16,223.6	260,519.7	16.1
Šumadija and Western Serbia	10,066.0	147,560.3	14.7
Southern and Eastern Serbia	6,157.7	112,959.3	18.3

Source: This table was created by the authors on the basis of data published by SORS - Statistical Office of the Republic of Serbia, 2023.

Assortment of apples in Serbia and the world

The most frequently cultivated apple variety in the Republic of Serbia is Idared, which takes up 41% of the total area under apple cultivation. The second most cultivated variety is Golden Delicious, which accounts for 14% of the total cultivated area. It is followed by Granny Smith (12%), Red Delicious (8%) and Jonagold (5%). Other varieties account for about 20% of the total area under apples. In the European Union, most varieties are represented, as evidenced by the high share of other varieties (48%), but the dominant variety on the territory of these countries is Golden Delicious with a share of 21% (Chart 1).

Chart 1. Leading varieties of apples produced in Serbia and the world in 2017



Source: This chart was created by the authors on the basis of data published by the SORS and WAPA[54], 2023.

In the USA, Red Delicious is the dominant variety with a share of 21%. Gala is the predominant variety in the following countries in the southern hemisphere: Argentina, Australia, Brazil, Chile, New Zealand and South Africa.

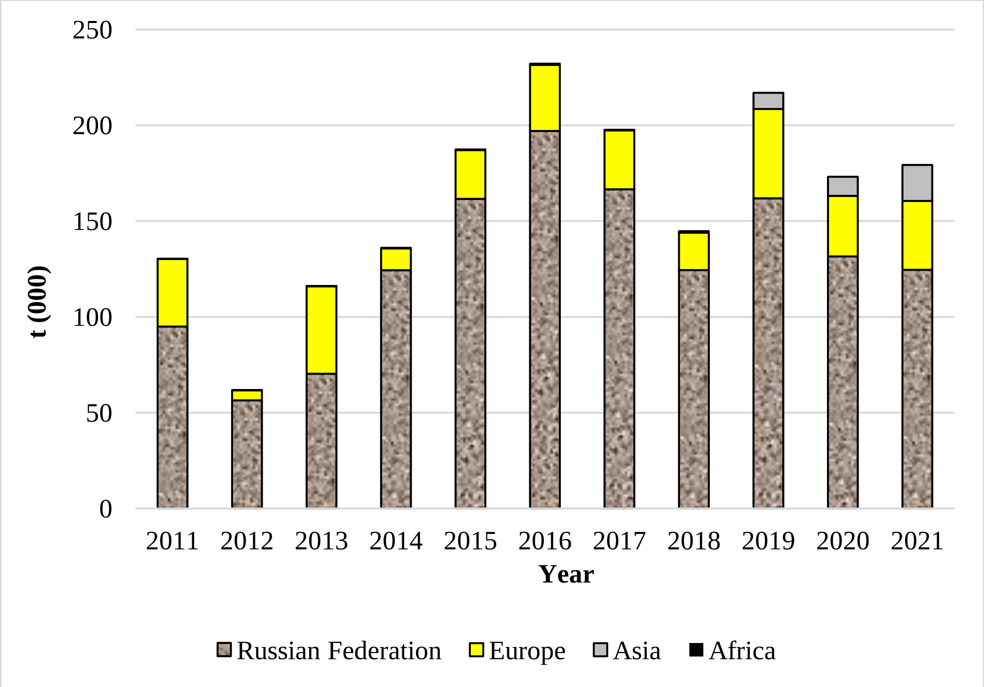
Export of apples from Serbia

According to FAO data, in 2021 Serbia ranked 12th in export of apples, amounting to 179,639 tonnes, which indicates its significant position in the world when it comes to foreign trade in apples.

Data from the last 10 years show that the main export destination for apples from Serbia is the Russian Federation (Chart 2).

[54] WAPA - The World Apple and Pear Association

Graph 2. Export of apples from Serbia to certain countries in the period from 2012 to 2021



Source: This chart was created by the authors on the basis of data published by the WITS[55], 2023.

On average, about 80% of apples destined for export ended up on the soil of the Russian Federation. Since 2019, the share of apple exports to the Middle East has been increasing, with the United Arab Emirates, Saudi Arabia, India, Qatar and Kuwait as leading importers. However, in recent years, our country's participation in exporting apples to the Russian market has decreased significantly. The main reason for this could be price competitiveness, where apples from surrounding countries (Moldova) are much cheaper, mainly due to much lower transport costs. Besides Moldova, Turkey and China have also appeared among the exporters of apples to the Russian market in recent years. Furthermore, the Russian Federation has reduced its dependence on apple imports in recent years by increasing its own production.

[55] WITS - World Integrated Trade Solution

Possibilities of applying agriculture 4.0. in the production and trade of apples in order to gain a competitive advantage

Business systems dealing with agricultural production are under increasing pressure due to several factors. One of the main reasons is the labour shortage caused by the White Plague, the out-migration of the indigenous population, the lack of desire of young people remaining in the country to engage in the production of primary agricultural products, and the existence of regulations restricting the movement of migrants who are potential labour. There is also considerable pressure from the rising cost of labour. One of the ways to combat this problem is through the application of information technologies in agriculture as part of the Industrial Revolution 4.0. In this sense, 3 areas for the application of information technologies in agricultural production can be identified: digital agriculture, automation and robotics, and precision agriculture.

For a long time, the major technological changes brought about by digitalisation had no impact on agriculture. In the last two decades, however, the situation in this area has changed noticeably. This is reflected in the indispensable presence of business systems from the agricultural sector in the "digital world", which is mainly reflected in the creation and maintenance of portals on the internet (websites). Digitalisation is also becoming increasingly important in foreign trade in agricultural and food products. New trends include the use of digital tools and online activities to make the entire supply chain more efficient, sustainable and transparent. Parties inside and outside the supply chain are increasingly demanding more accurate information from producers to limit risks, plan sales and provide tracking information. This includes sharing information on pesticide use, crop forecasts and fruit quality, but also sharing data for regulations and certification (van Haarlem, 2020).

Smart logistics in transport and blockchain technology are increasingly used to reduce costs. Blockchain systems allow any actor in the supply chain to track the movement of goods through the supply chain, monitor the movement of containers in real time and view the status of customs documents. In addition to tracking goods, blockchain technology can also encrypt important documents (e.g. quantities, prices and contracts) (De Clercq et al., 2018). One of the most convenient free solutions for exporters from developing countries is to use available websites such as "Trade Map" or "Tridge". These websites contain a large amount of processed data on international fruits and vegetable trade, which can be used to analyse the market attractiveness of a product and to select the most promising markets. In this way, digitalisation has the potential to create new jobs, bridge the economic gap between rural and urban areas and provide farmers with better market access (Javaid et al., 2022).

Automation and robotics technology has been used for many years in various sectors of the economy, but in recent years it has also found its application in agriculture. The main motive for developing automation in agriculture is to reduce the seasonal labour force. Attempts to introduce robots for fruit harvesting and other fruit production operations have been made since the first robots began to operate in industrial settings. However, a very undefined biological environment such as an orchard made it quite difficult to develop robots that would perform these tasks (Zujevs and et al., 2015).

Indeed, robots are emerging that many economies see as a permanent solution to the problem of labour shortages in the future. It is therefore no coincidence that one of the fastest growing sectors in the technology industry is precisely robotics.

This is illustrated by the example of the Californian robotics company Advanced Farm, one of several robotics companies conducting field trials in Central Washington. Their 4.3 m tall robotic apple harvester is powered by a computer that independently controls the movements of six surprisingly nimble mechanical arms. Each of these "hands" is equipped with a suction cup at the end, the design of which prevents mechanical damage to the fruit during picking. Built-in cameras locate each apple and assess whether it is ripe enough to pick. The picked apples are lowered by a robot into a transport system that takes them to a human operator who manually removes the woody parts to prevent the apples from being damaged when they are packed into boxes and prepared for distribution. This is an operation that robots cannot currently perform. After all the apples in a given area have been picked, the robot moves on and repeats the process. This robot can work 24 hours a day so that the harvest can be completed on time.

But robots that pick apples from the air are also in the testing phase. The Israeli robotics company "Tevel Aerobotics" has constructed a robot consisting of eight autonomous flying drones. Each of them is equipped with sensors that detect the location and ripeness of each apple, as well as a small stick to which a suction cup is attached. When the sensor determines that the apple is ready to be harvested, the fruit is picked from the tree with a suction cup. The picking method is based on suction, which involves gentle rotation and mimics the precision of manual picking. The drones are attached to a long, flat conveyor belt with cables - like floating tentacles.

Currently, humans are still faster and more efficient than most picking robots, but this gap is closing year by year. In the coming time, we can expect a future where humans and robots work together in orchards and farms. It is expected that by the beginning of the next decade, machines will be able to pick most of the fruit, and then a smaller team of humans will be able to pick the rest of the fruit.

Until then, growers will be trying to figure out how to employ enough labour for harvesting until this technology is developed to a satisfactory level. Concerns about the availability of skilled harvesters remain a priority for most growers.

In their work, Wang et al. (2022) analysed the characteristics of five types of apple-picking robots, of which only one had been introduced into the market by then. Therefore, automation and robotics developed the most in the post-harvest stage, i.e. the stage of calibrating, sorting and packaging the products for the final consumer. Different types of calibration machines have been developed to meet these requirements. An example of such a machine is the calibrator of the company "Maf Roda" with a capacity of 10 t/h. This machine with its sophisticated HD and IR camera technology offers the possibility to divide the calibre and colour of apples into 12 categories, as well as all types of packaging. In fact, with the help of HD and IR cameras, each apple is captured from 10 different angles, with the software categorising the apple according to size, weight and percentage colouring.

One of the best-known applications of information technology in agriculture is precision farming. The basic task of precision agriculture is to maximise yields with optimal use of agricultural inputs, in such a way that each crop in a field gets exactly the resources it needs. The application of precision agriculture requires the use of digital information, which agricultural producers can obtain from a variety of sources as needed: Photos of fields from drones or satellites, installation of sensors in the field such as soil moisture sensors, temperature sensors, etc. (Zolkin et al., 2021). Precision irrigation is part of the concept of precision agriculture introduced in the 1990s, which has the potential to ensure sustainable water use in agriculture. It is based on the use of an automatic irrigation system programmed to start and stop automatically when soil moisture is below or above optimum. The most common equipment for "precision farms" are meteorological stations, which are equipped with a range of intelligent agricultural sensors. Meteorological stations measure data such as temperature, precipitation, soil moisture, wind strength and more. The meteorological station sends all this data to a dedicated website where it is available to the producer 24 hours a day. Users also have access to software for predicting the occurrence of diseases in specific crops.

The need for constant monitoring of crops and large fruit growing complexes requires a lot of time and the constant use of experts to carry out this task. In addition, some changes and problems that occur on the plant itself (lack of water and nutrients, the appearance of diseases and pests) cannot be detected in time with the naked eye. The moment someone manages to detect the problem with the naked eye, it is already too late, because the plant has suffered a certain amount of stress, which manifests itself in a decrease in yield and quality or, in the worst case, in the death of the plant itself. For this reason, techniques have been developed today to assess the condition of plants even before visible symptoms appear. These techniques are known as scanning technologies or plant imaging technologies, which are based on determining the spectral reflectance index of plants. The measurement of spectral reflectance of plants on large complexes is based on the use of multispectral cameras on satellites or aircraft (planes, drones) and the subsequent processing of the images (Pajić et al., 2022).

Conclusion

The analysis of apple exports from Serbia in the period from 2012 to 2021 shows that, despite a decline, the largest quantities were exported to the Russian Federation. In addition, exports of apples to Middle Eastern countries have increased in recent years, and these markets are compensating for lower exports to Russian Federation. From the analysis of fruit growing sector in Serbia it can be concluded that the use of information technologies is most widespread in apple production and thus has the greatest influence on the expansion of their use in other branches of fruit production. This statement is supported by the fact that there are leading companies in Serbia involved in the production, storage and trade of apples, using modern technologies, including digital technologies, on a large scale, which is not the case in the production of other fruits.

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Pollen Germination and Pollen Tube Growth as a Potentially Important Traits for Successful Pollination and Fertilization of Apple[56]

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Abstract

In apple orchards are lately increasingly introduced new, mostly club varieties such as Pink Lady, Fuji, Modi, etc., because they achieve a better price on the market. Before introducing these varieties into production, it is necessary to examine their production and technological properties. The aim of this work was to examine pollen germination and pollen tube growth in four apple varieties ('Gala', 'Modi', 'Fuji' and 'Pink Lady') and one genotype ('Viola'), which is used only as a pollinizer in orchards. Pollen germination and pollen tube growth were analysed by method *in vitro* on culture medium containing sucrose and agar-agar. Pollen germination ranged from 63.61% ('Viola') to 83.05% ('Fuji'), and pollen tube length from 380.96 µm ('Viola') to 2524.36 µm ('Modi'). With the exception of the 'Viola' genotype, the studied cultivars were characterized by high pollen germination and favourable pollen tube growth, which makes them potentially suitable pollinizers in apple orchards.

Key word: *Malus domestica* Borkh., pollen germination, pollen tube length, yield

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Introduction

In terms of production, the apple ranks third among fruit trees in the world, behind citrus fruits and bananas. However, among temperate fruit trees in terms of production, it ranks first in the world. The average annual production of apples in the world (2016-2020) is 85,609,942 t (FAOSTAT, 2022). Over 60% of production is located in Asia. The world's largest producer of apples is China (40,788,360 t). It is followed by the USA, Turkey, Poland, India, Iran, Italy and Russia (Radović, 2022).

The average annual production of apples in Serbia for the period (2016-2020) was 445,705 t (FAOSTAT, 2022). The main apple production areas in Serbia are the Zapadna Morava Valley, Smederevo - Podunavlje, Južni Banat, Fruška Gora, Bačka and Šumadija.

Apple is a type of fruit tree that is characterized by extremely high yields per area unit. In order to achieve high yields, it is very important to carry out successful pollination and fertilization, as well as to implement all necessary agro-technical and pomo-technical measures (pruning, thinning of the fruits, plant protection, irrigation and use of fertilizers).

For successful pollination and fertilization of apples, it is very important that the varieties are characterized by high pollen germination. Pollen germination and pollen tube growth are influenced by a number of factors. They can be classified into two groups: genetic and environmental. One of the most important factors affecting pollen viability is genotype (Stösser et al., 1996; Radović et al., 2015). In the case of apples, there are varieties that are characterized by poor pollen germination. These are mostly triploid varieties and as a rule, they cannot be used as pollinizers (Radović, 2022).

Of the environmental factors, air temperature of has the greatest influence on pollen germination and pollen tube growth (Pirlak, 2002; Radović et al., 2016a; Radović et al., 2020). In years when air temperatures are low during flowering, the growth of pollen tubes is often slowed down, which results in weaker fertilization and fruit set (Zebro et al., 2023). Therefore, in such years, yields are often significantly lower than expected. In addition to these, pollen germination and pollen tube growth are also affected by boric acid (Imani et al., 2011; Liu et al., 2013), plant growth regulators (Bolat and Pirlak, 2003; Radović et al., 2016b), fungicides (Yi et al., 2003) and heavy metals (Gür and Topdemir, 2005).

The aim of this work was to examine pollen germination and pollen tube growth in five apple genotypes.

Material and methods

Research was carried out at the Experimental Station ‘Radmilovac’ of the Faculty of Agriculture, University of Belgrade during the two-year period (2020 and 2021). Pollen from four apple varieties: 'Gala', 'Modi', 'Fuji' and 'Pink Lady' and one small-fruited genotype ('Viola'), which is used as a pollinizer in orchards, was used as the test material. The rootstock was M9, and the growing form is a slender spindle.

Before starting the analysis, one-year old shoots with flower buds were removed from the trees in the ‘balloon’ stage and transferred to the laboratory. Anthers were separated from flower buds and placed in Petri dishes. Separated anthers were left in open Petri dishes for 24 h at room temperature, in order to dry them and extract pollen from them. Then, pollen from each variety was sown with fine brushes in Petri dishes (Ø 9 cm) on a previously prepared nutrient medium consisting of 15% sucrose and 0.7% agar-agar.

The sown pollen was left for 24 h at a temperature of 20ºC, after which the pollen was observed under a ‘Leica DM LS’ light microscope (Leica Microsystems, Wetzlar, Germany) in order to determine its germination. The experiment was set up in three repetitions and in each repetition at least 300 pollen grains were analyzed. Pollen was considered germinated if the length of the pollen tube was longer than the diameter of the pollen grain.

The length of the pollen tubes was measured on images taken under a microscope using the ‘Leica IM 1000’ program. From each variety, 80 pollen tubes were measured.

The obtained results were statistically processed using the method of two-way ANOVA. Individual testing was performed using the Tukey test at the $P \leq 0.05$. Data analysis was performed using the statistical software package ‘Statistica’ (StatSoft, Inc., Tulsa, Oklahoma, USA).

Results and discussion

Pollen germination is a trait greatly influenced by genotype (Petrisor et al., 2012). In our work, it was determined that it varied significantly between the tested genotypes and by the years of the research (Table 1).

All tested genotypes were characterized by high pollen germination (over 60%) (Figure 1). The highest pollen germination was found in the

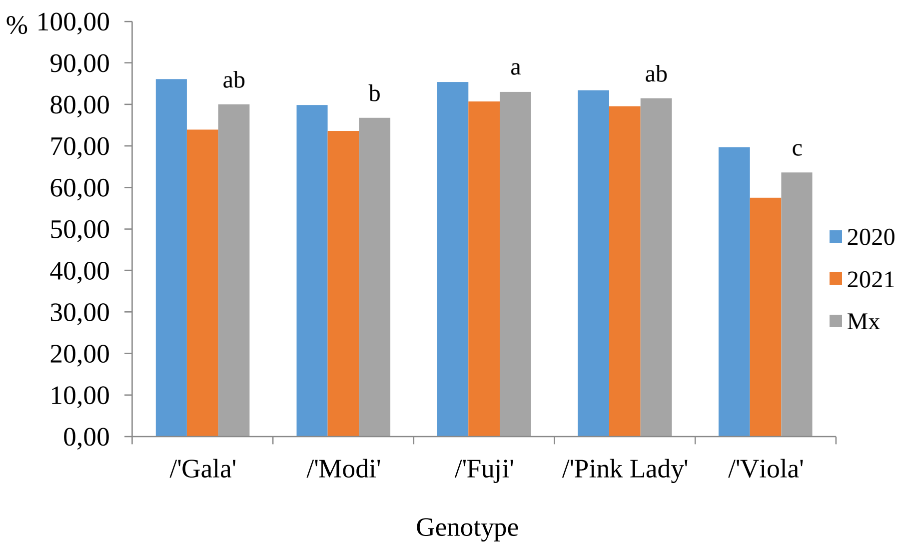
'Fuji' variety (83.05%), which was statistically significant in compare to pollen germination of varieties 'Modi' and 'Viola'. Our results regarding high pollen germination of 'Fuji' variety are supported by previous literature data (Zebro et al., 2023). The pollen germination of the genotype 'Viola' was significantly lower in compare to pollen germination of other tested varieties (Figure 1). Differences in pollen germination between studied genotypes are presented in Figure 2.

Table 1. Analysis of variance for pollen germination and pollen tube length

Source of variation	Pollen germination		Pollen tube length	
	df	Mean squares	df	Mean squares
Genotype	4	366,9**	4	4015769**
Year	1	457,9**	1	2787164**
Genotype x Year	4	24,5nz	4	322042**
Error	20	11,8	20	44935

**$p \le 0,01$; ns not significant

Figure 1. Pollen germination in apple (%)

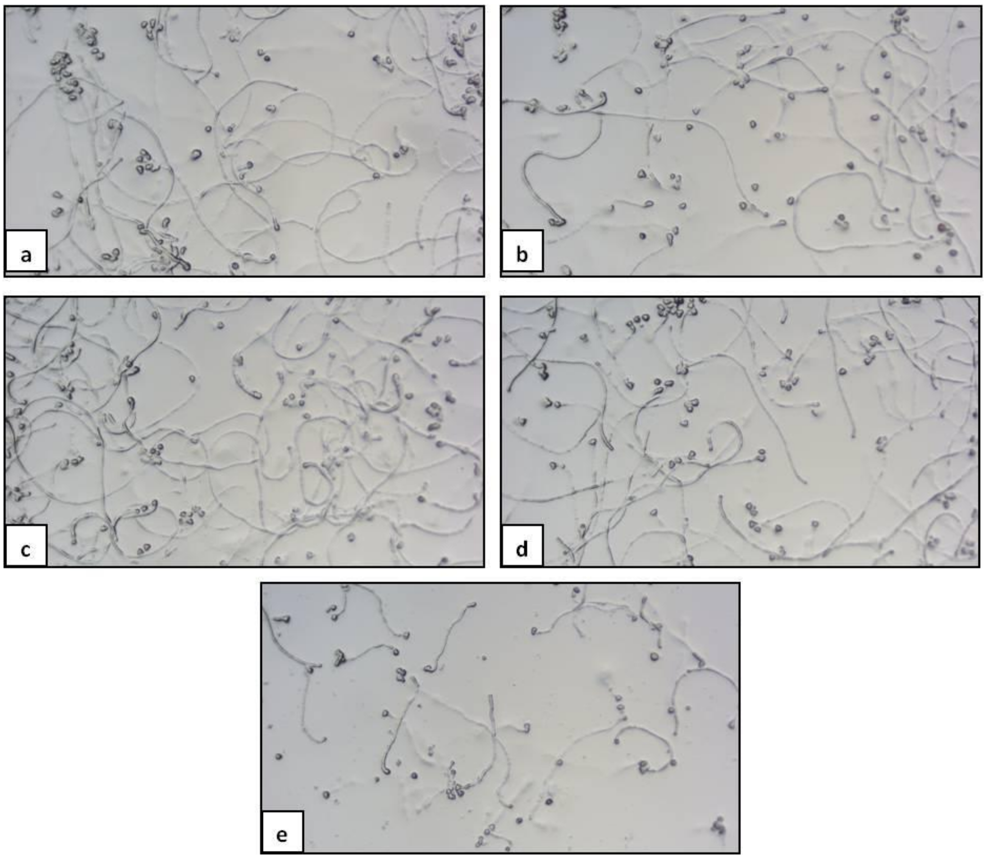


Mx - *Mean values*

Mean values followed by different letters (a, b, c) are different significantly by Tukey's test at P≤0.05

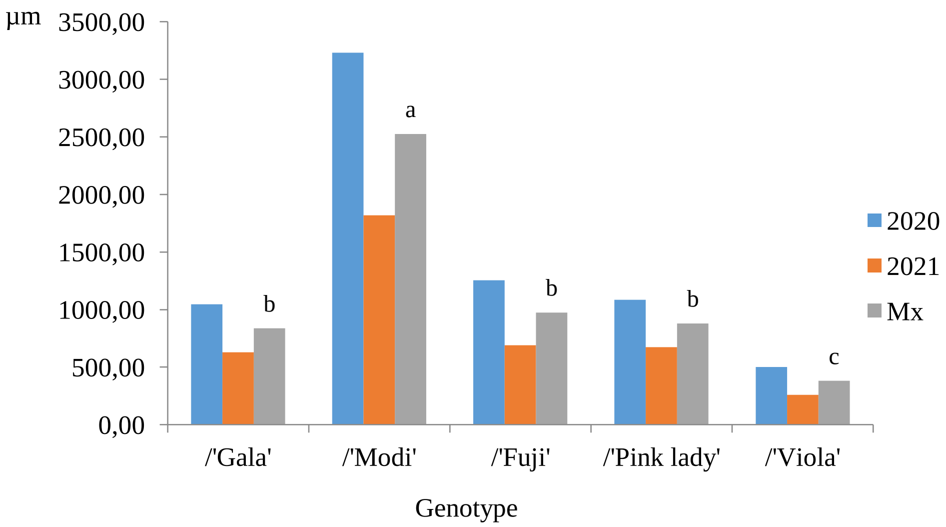
In addition to the genotype, pollen germination differences are registered between the years of the study. It was significantly higher in the first year of research (80.88%) compared to the second year (73.07%). In 2020, the highest pollen germination was found in the 'Gala' variety (86.06%), while in 2021 it was the highest in the 'Fuji' variety (80.68%). The 'Viola' genotype was characterized by the lowest pollen germination in both examined years (69.68% and 57.55%, respectively), in compare to other varieties. This variation in pollen germination by year is a consequence of different weather conditions, primarily the air temperature at the time of pollen formation (microsporogenesis process).

Figure 2. Pollen germination in apple: a) 'Gala'; b) 'Modi'; c) 'Fuji'; d) 'Pink Lady'; e) 'Viola'



Some authors previously determined a significant influence of temperature on pollen germination in apples (Yoder et al., 2009). In addition to apple, it is recorded that temperature has significant effect on pollen germination in pear (Radović et al., 2016a), quince (Radović et al., 2020), sour cherry (Milatović and Nikolić, 2014), apricot and sweet cherry (Pirlak, 2002).

Figure 3. Pollen tube length in apple (μm)



Mx - *Mean values*
Mean values followed by different letters (a, b, c) are different significantly by Tukey's test at P≤0.05

Similar to pollen germination, pollen tube length varied significantly between apple genotypes (Table 1). The variety 'Modi' was distinguished by the longest pollen tubes (2524.36 μm). This variety had significantly longer pollen tubes compared to the other varieties. On the other hand, similar to pollen germination, the shortest length of pollen tubes (380.96 μm) was determined in the 'Viola' genotype. This genotype had a significantly shorter length of pollen tubes compared to other varieties. Varieties 'Gala', 'Fuji' and 'Pink Lady' did not differ significantly from each other in terms of this trait (Figure 3).

In addition to the genotype, the length of the pollen tubes also varied significantly according to the years of research. In the first year, it was almost double (1424.08 μm) compared to the second year (814.47 μm). Similar to pollen germination, air temperature was a significanc source of variation of the pollen tube lenght. It is confirmed that incerase of temperature, accelerates the growth of pollen tubes of apple (Yoder et al., 2009), pear (Radović et al., 2016a) and sour cherry (Milatović and Nikolić, 2014).

Conclusion

Pollen germination and pollen tube length differed significantly between the studied apple genotypes. The 'Fuji' variety had the highest pollen germination, while 'Modi' variety had the longest pollen tube length. The lowest pollen germination and the length of the pollen tubes were found in the 'Viola' genotype. All tested varieties, except the 'Viola' genotype, can be recommended as potentially good pollinizers in apple orchards.

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Influence of Sowing Depth on the Productivity of *Melissa officinalis* Seedlings[60]

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Abstract

Melissa officinalis, popularly known as lemon balm, native to the eastern Mediterranean region and western Asia, is a highly valuable medicinal and aromatic plant species used throughout the world. This study aimed to examine the productivity of rootstock seedlings based on cultivation at different depths in a sheltered area. The experiment was conducted at the Institute for the Study of Medicinal Plants "Dr. Josif Pančić" in Belgrade, where the seeds of lemongrass were sown at three different depths I: 0.2-0.5 cm; II: 0.6-1 cm; III: 1.1-1.5 cm and then placed in controlled conditions with continuous monitoring and measurement of sprouted plants. The best performance was achieved with shallow sowing (0.2-0.5 cm) and in the first treatment (73.1; 44.5; 48.3). During the first morphological analysis (34 days after sowing), the most pronounced influence of sowing depth was on plant height. In the last morphological analysis (78 days after sowing), the influence of sowing depth was manifested in all treatments.

Key words: medicinal and aromatic plants, lemon balm, plant height, leaf

Introduction

Nowadays, according to the data of the World Health Organization, there are around 20,000 medicinal and aromatic plants of useful value around the world. Generally, about 80% of the world's population uses medicinal plants in traditional medicine for the treatment of diseases and

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ailments. Of the total number, 4,000 plants are still in wide use, and only 2,000 of them in the world and 500 in Western Europe have a large commercial potential today. (Avci et al. 2016). One of the most important commercial plant species, whose herb and leaf are exploited in several ways, as a dietary supplement, herbal tea, ingredient in cosmetics, etc. is *M. officinalis* or popularly known as motherwort (Świąder et al. 2019). *M. officinalis* is a perennial plant of the *Lamiacae* family. It occurs naturally in the Mediterranean and Western Asia, but is cultivated throughout Europe and North America and is characterized by its unique lemon flavor and aroma (Koch-Heitzmann et al., 1988). In Europe, it has traditionally been used to relieve neurogenic disorders, insomnia and stress due to its spasmolytic and sedative properties (Kennedy et al., 2002). Other studies indicate that lemon balm can be effectively used to prevent various health problems such as modulating cognitive performance and improving non-alcoholic steatohepatitis and as anti-Alzheimer's disease and diabetes (Chung et al., 2010; Kim et al., 2020). Literature data indicate a positive antibacterial and antioxidant effect of its essential oil (De Sousa et al., 2004). Due to all the mentioned positive effects, motherwort is grown in many countries, which attracts continuous interest in improving and promoting its mass production. Plantation production of rootstock is based on seedlings, produced in cold beds, which are later planted in the open field in early spring or mid-autumn at a density of 47,600-66,000 seedlings/ha (Stepanović, 2011). According to the literature, early production of quality seedlings results in a greater number of harvests during the first year, which is directly reflected in a more positive economic justification of production (Saglam et al. 2004; Gurčík et al. 2005). Namely, the research by Mihajlov et al. (2013), show how direct sowing of motherwort during the first year yielded 11 times lower yield (about 500 kg/ha) than in the second (6,775 kg/ha). In that case, the profitability of production in the second year ($6,150/ha) is almost 14 times lower, and this probably stems from the inadequate production of planting material. According to Adeogun et al. (2012), the success in the production of seedlings primarily depends on the reproductive material (seeds) and its proper distribution in the surface layer both horizontally (in length) and vertically (in depth). The depth of sowing mostly depends on the size of the seeds, soil characteristics, humidity and moisture distribution in the soil and on the time of sowing. Depending on the plant species, some seeds are sown deeper for better rooting, while the seeds of some plant species are sown on the surface without any cover.

According to the literature, seed size has a great influence on the determination of sowing depth (Willenborg et al., 2005). In addition, one of the important factors is the soil texture because the physical characteristic of the soil also makes it difficult to determine the ideal sowing depth (Zuo et al., 2017). Generally, on moist soils with a heavier mechanical composition, it is preferable to sow the seeds at a shallower depth, while in arid regions, on soils with a lighter mechanical composition, the seeds should be sown at a shallower depth. If the seeds are sown too deep, due to too much moisture and lack of oxygen, they will have difficulty germinating and it is difficult for the seedlings to break through the surface layer of the soil because the germination energy is reduced due to the loss of nutrients. On the contrary, shallowly sown seeds for large crops can be exposed to lack of moisture, easy freezing and are more exposed to various animal influences, which is significantly less negative than too deep sowing (Findura et al. 2008).

Generally, for most commercial species, researchers have described in detail how sowing depth affects growth and development, which is not the case with *M. officinalis.* Earlier literature reports indicate that during the formation of a cold bed in field conditions, *M. officinalis* seeds are placed at a depth of 0.5 cm to 1 cm, which results in between 200-300 quality seedlings per m² (Stepanović, 2011). However, for the production of container seedlings, there is still no precise information available about the specific desirable seed depth of this cultivar. In this regard, this study aimed to evaluate the influence of sowing depth on the emergence and morphophysiology of *M. officinalis* container seedlings grown under controlled conditions.

Materials and methods

Plant material

During the experiment, reproductive material (seeds) from the collection of the Institute for the Study of Medicinal Plants "Dr. Josif Pančić", Pančevo, Serbia (44° 52'20.0" N, 20°42'04.7") was used, whose mass of 1000 seeds was 0.43 g.

Treatments

In the second decade of September 2020, an experimental trial was set up at the Institute for the Study of Medicinal Plants "Dr. Josif Pančić" in Belgrade. The experimental design was a randomized block with four replications designed so that each experimental unit contained uniform motherwort seeds sown at three different depths: I: 0.2-0.5 cm; II: 0.6-1 cm; III: 1.1-1.5 cm. Each experimental unit consisted of a plastic container with a volume of 36 dm^3 (60x40x15 cm) and an area of 0.24 m^2. Plastic containers were filled with commercial substrate "Cultivo I SF" granulation: 0 - 5 mm; nutrient content: NPK 18:10:20+Mg+me in the amount of 1 kg/m^3, slow-acting fertilizer: RADIGEN®- Jost GmbH in the amount of 50 g/m^3; hydrogel in the amount of 1 kg/m^3. Then, 1200 seeds (about 0.5g) were sown in each plastic container at the specified depth, because according to the literature, 2-3 g of seeds per m^2 are recommended (Stepanović, 2011).

Plant production

The sown containers are placed in a polyethylene tent (Grow Box), in the following growing conditions: air humidity from 40 to 60%; air temperature from 20 °C to 25 °C, with lighting regulation using fluorescent tubes with a photoperiod of 12 h, while the substrate was maintained at moderate humidity and a temperature of 21±2 °C. Air temperature and relative humidity in the Grow Box were monitored using a data logger (HAXO-8), and substrate temperature using a thermometer (Testo 110). The water content in the substrate was monitored and maintained daily with continuous watering. The sprouted seedlings were counted daily, and after stabilization of sprouting and the appearance of the first true leaf at the end of October 2020 (34 days from sowing), they were transplanted into styrofoam containers with 160 holes filled with the same substrate (Cultivo I SF). More precisely, 160 uniform plants (4x160) were selected from each treatment, which were transplanted into and then re-placed in a polyethylene tent (Grow Box) with continuous watering. Seedlings in containers were kept in a polyethylene tent (Grow Box) until the need for replanting (78 days from sowing), after which their morphological analysis was performed.

Measurement and statistical analysis

After sowing, the analysis of sprouted seedlings was performed and defined:

1) The percentage of sprouted plants (%) determined based on the count of seedlings after stabilization of the stand. A seedling whose cotyledon was visible above the substratum was considered a seedling.

2) Emergence Speed Index (ESI): determined according to Maguire (1962):

$$ESI = N1/D1 + N2/D2 +... Nn/Dn$$

N1= number of sprouted seedlings on the first day; Nn= accumulated number of sprouted seedlings; D1= first day of counting; Dn= number of days after sowing

3) Mean emergence time (MET - days): estimated according to the equation proposed by Labouriau (1983):

$$MET = (\sum Ni \times Ti) / \sum ni$$

Ni = number of sprouted seedlings per day; Ti = evaluation time (days)

After transplanting into containers after **34 days**, the following was determined:

4) Number of leaves per plant (no. plant-1): obtained count of the number of leaves on each plant;

5) Number of leaves per plant (no. plant-1): obtained count of the number of leaves on each plant;

6) Stem diameter (mm): measured at the height of the plant wing using a digital meter reading (Clarke, 150 mm), with an accuracy of ± 0.01 mm;

7) Plant height (cm): determined from the surface of the soil to the insertion of the last leaf with a millimeter ruler;

At the end of seedling production, **after 78 days** from the start of production, the parameters listed under numbers 4 to 7 were measured.

The obtained data were subjected to homogeneity analysis, where it was not necessary to transform them. In that case, the results were statistically processed using a one-factor analysis of variance (ANOVA), comparing mean values using Duncan's test ($p<0.05$) using SPSS software.

Results and discussion

The obtained results on the assessment of seedlings are shown in Table 1, and the results of the morphological characteristics of seedlings in different stages are shown in Tables 2 and 3.

Table 1. Evaluation of sprouted seedlings

Treatments	Bi (%)	KB (plant per day)	IPB
I	73.1±0.13a	44.5±0.16a	48.3±0.21a
II	63.2±0.23b	33.3±0.25b	41.8±0.18b
III	38.3±0.19c	23.4±0.32c	23.8±0.24c

*I-depth 0.2-0.5 cm; II – depth 0.6-1 cm; III-depth 1.1-1.5 cm; Bi-percentage of sprouted plants; KB-mean time of germination of plants per day; IPB-Index of speed of appearance; values in the column marked with the same letter are not statistically separated.

According to the results of the parameters for the assessment of sprouted plants (Table 1), we can state that the depth of sowing had a different effect on them. Seeds planted at a shallower depth (Treatment I) had the best percentage of sprouted plants. More precisely, in treatment I, the percentage of sprouts was 12.64 % and 44.4 % higher than treatments II and III. The average germination time per day in treatment I was 25.1 % and 47.4 % higher than treatments II and III. Also, there were differences in the plant emergence index and treatment I proved to be the most effective by about 13 % and 50 % of treatments II and III. Taking into account that the sowing of *M. officinalis* was done in a uniform substrate, based on the results we can state that the sowing depth had the greatest influence on the result of the measured parameters in the previous treatments. According to the literature, the sowing depth of seeds can have the greatest influence on the regulation of the flow of water and air absorption (Kovačević et al., 2018). We assume that the stated reason had a significant impact on our achieved result as well, because shallower sown seeds had better air circulation.

Table 2. Morphological characteristics of seedlings after 34 days

Treatments	BL (leaf per plant)	PS (mm)	VB (cm)
I	3,8±0.21a	1.21±0.10a	5,7±0.10a
II	3,7±0.33a	1.19±0.12a	4,1±0.11b
III	2,8±0.29b	1.18±0.14a	3,5±0.13c

*I-depth 0.2-0.5 cm; II – depth 0.6-1 cm; III-depth 1.1-1.5 cm; Bi-percentage of sprouted plants; KB-mean time of germination of plants per day; IPB-Index of speed of appearance; values in the column marked with the same letter are not statistically separated.

Based on Table 2, it can be seen that the sowing depth had the greatest influence on the number of leaves per plant (BL) and plant height (VB), while the sowing depth did not affect the stem thickness (Table 2). Treatment III had the lowest number of developed leaves, while the plants of treatment I had the highest height. Generally, the height of plants in treatment I was about 9 % and 18 % higher than plants in treatments II and III. According to the literature, with a large seeding depth, there is a great stress on the plants and weaker sprouting, because in that case there is a large expenditure of energy required for germination, which can later affect further development. Accordingly, we assume that this is one of the biggest reasons for the manifestation of morphological variability. Probably, according to Ke (2001), plants that have developed earlier have a better-developed photosynthetic apparatus, which enables them to produce better assimilates and, at the same time, to develop faster in the later stages of development.

Table 3. Morphological characteristics of seedlings after 78 days

Treatments	BL (leaf per plant)	PS (mm)	VB (cm)
I	4,9±0.19a	3.11±0.10a	8,7±0.10a
II	4,1±0.23b	3.09±0.12a	8,1±0.11b
III	3,9±0.26b	3.08±0.14a	7,9±0.13b

*I-depth 0.2-0.5 cm; II – depth 0.6-1 cm; III-depth 1.1-1.5 cm; Bi-percentage of sprouted plants; KB-mean time of germination of plants per day; IPB-Index of speed of appearance; values in the column marked with the same letter are not statistically separated.

After 78 days of growing motherwort seedlings, a significant effect of sowing depth on the number of leaves per plant as well as on plant height was observed, while sowing depth did not affect stem thickness (Table 3). Generally, the best habitus was achieved in seedlings from treatment I (Table 3). More precisely, seedlings from treatment I had about 15-20% more leaves than treatments II and III, which probably had a positive impact on leaf yield. A similar outcome in this measurement for PS and VB parameters was as in the previous measurement. The thickness of the stem was similar in all treatments, but the height of the plant was slightly higher (about 6-10%) in the first treatment, unlike the others. A similar research result was obtained by Aisenbeg et al. (2014), who verified the significant influence of sowing depth on the emergence and morphological traits of soybeans. Generally, the obtained results indicate a better productivity of seedlings and seedlings grown in controlled conditions at a shallower depth than in the literature Stepanović, B. (2011), where the production of seedlings was carried out in a cold bed. More precisely, the production of rootstock seedlings in a protected area achieves 2-3 times better productivity of planting material. In that case, the profitability of the production would be significantly more pronounced, because a larger number of harvests in the first year would contribute to an even greater economic justification of this plantation production. Accordingly, and based on the previous statements of Stepanović, (2011), we assume that instead of 1-2 t of herbs per ha, we would have 2-2.5 t of herbs per ha, and that would increase the profit of this production by about 25 % in the first year. In that case, production would be 5 times more profitable than Mihajlov et al. (2013), because the mother plant was sown immediately in an open field and ready for development.

Conclusion

According to the outcome of this research, we can conclude that by regulating the growing conditions, it is possible to obtain quality seedlings of mother plants in a short time interval, which can later be planted in the open field and directly affect the improvement of production productivity. The depth of sowing seed material had a great influence on the percentage of seed germination and later on the morphological characteristics of the seedlings themselves. Therefore, when growing this species in a protected area under controlled conditions, shallow sowing is recommended, that is, sowing at depths between 0.2 and 0.5 cm. The outcome of this research recommends the producers sow the seeds of motherwort at a smaller depth in the appropriate commercial substrate and the specified controlled conditions, which achieves a fast and uniform production of planting material. In this sense, plantation production can start much earlier and thus a greater number of harvests can be achieved during the first year of cultivation, which greatly increases the profitability of production.

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Comparative Analysis of Innovation Indicators in the Agri-Food Sector in Serbia and the Countries of the Region[63]

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Abstract

The process of globalization and the development of new technologies have led all sectors, including the agri-food sector, to rely on innovation to be more competitive in the world market and contribute to the development of the national economy. However, the implementation of innovations in Serbia and the countries of the region is a very complex and limited process. For this reason, the objective of this paper is to review and compare innovation indicators in the agri-food sector in Serbia and the countries of the region for the period from 2015 to 2020, in order to identify areas where improvements are needed to achieve better results.

The Global Innovation Index model adapted to the agri-food sector and presented in The Global Innovation Index - Innovation Feeding the World 2017 was used. Data for the preparation of the paper were taken from the following databases: UNESCO Institute of Statistics, FAOstat, USDA, UPOV, World Bank, UN Comtrade Database, and WIPO.

Key words: agricultural and food sector, Global Innovation Index, Serbia, countries in the region

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Introduction

The agricultural and food sector is one of the most important sectors of the economy both in the Republic of Serbia and in the countries of the region and has a significant share in the gross domestic product. However, the agricultural and processing sector is exposed to numerous risks, primarily production, which is reflected in the uncertainty of future yields due to unpredictable weather conditions, and the market, which brings fluctuations in the prices of agricultural products, as well as numerous challenges such as food security, sustainable resource management, economic crisis, etc.

In order to successfully respond to the above challenges, innovations and new technological achievements in the field of agriculture must be applied. The combination of the latest technological achievements, such as temperature and humidity sensors, satellite imagery, automated robots, GPS technology, etc., is presented in the framework of Agriculture 4.0 (Clercq et al., 2018). By applying the mentioned modern innovations, farms would achieve higher production while saving significant resources (Polovina et al., 2020), making them more profitable and competitive in the global market.

In Serbia and the countries of the region, the implementation of Agriculture 4.0 is a very complex and limited process due to the dominance of small farms with fragmented operations, old mechanization and an unfavorable age structure of farm owners. For this reason, the objective of this work is to review and compare the innovation indicators derived from the Global Innovation Index in the agriculture and food sector in Serbia and the countries of the region in the period from 2015 to 2020, in order to identify areas where improvements are needed to achieve better innovation performance.

Method of work

One of the indicators used to measure the innovation performance of countries around the world, including Serbia and all selected countries in the region, is the Global Innovation Index (GII). It is calculated based on the average of two sub-indices: Innovation Potential (Input) Sub-Index and Innovation Outcome (Output) Sub-Index, where the Innovation Potential Sub-Index consists of five pillars - Institutions, Human capital and research, Infrastructure, Market sophistication, and Business sophistication, while the

Innovation Outcome Sub-Index inclues of two pillars - Knowledge and technology outputs, and Creative outputs (WIPO, 2020).

The report *The Global Innovation Index - Innovation Feeding the World*, published in 2017, proposed a model to measure innovation in the agri-food sector based on the GII. By applying this model, i.e., according to the innovation capacity of the agri-food sector, countries are not ranked, but this model includes indicators that can be used for comparison. Based on the GII pillars adapted to the agri-food sector, this paper uses the following indicators: under the first pillar: Human capital and research - Percentage of graduates from tertiary education graduating from Agriculture programmes; under the second pillar: Market sophistication - Credit to agriculture; under the third pillar: Business sophistication - Use of mineral fertilizers and agricultural machinery; under the fourth pillar, Knowledge and technology outputs - Plant varieties registered, Gross value added per worker in agriculture, and Agri-food exports; under the fifth pillar, Creative output – Agri-food industrial designs and Agri-food trademarks.

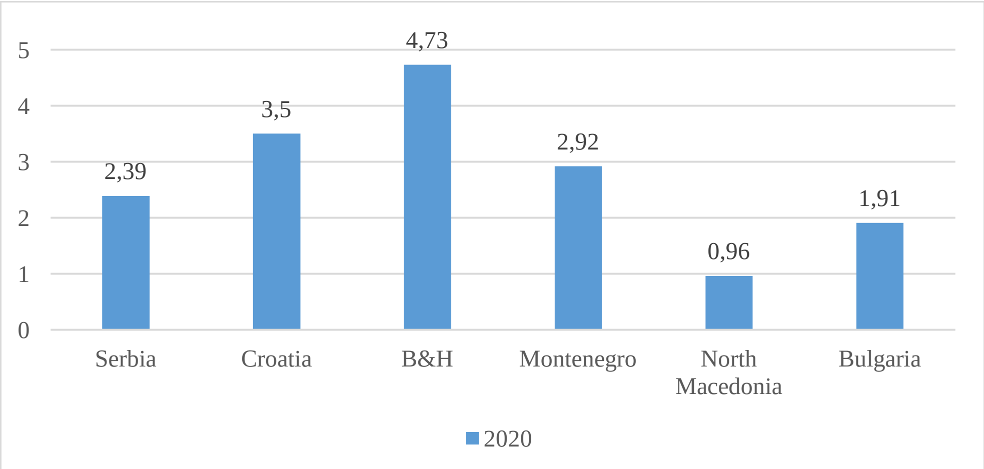
The following databases were used for the preparation of this paper: UNESCO Institute for Statistics, FAOstat, USDA, UPOV, World Bank, UN Comtrade Database and WIPO, as well as numerous publications and professional papers.

Research results

The first pillar of the GII is Human capital and research. People's knowledge, skills, education and research largely determine an economy's innovation potential, productivity, competitiveness and economic growth. For this reason, investments in human capital development and research are very important, especially due to the modern scientific and technological revolution, which has led to rapid and sudden changes, where modern society needs to absorb, process and disseminate a huge amount of information (Mitrović et al., 2019). The growth of human capital not only enables faster and easier adoption of advanced technologies from abroad, but also creates new technologies through innovation (Švonja, 2017). Most economists agree that knowledge and innovation are the basis of the entire economic development (Mitrović and Mitrović, 2015) and are therefore crucial for the improvement of the agri-food sector.

Since education contributes to the accumulation of human capital, one of the indicators of innovation in the agriculture and food sector is the share of graduates in agriculture, forestry, fisheries and veterinary in the total number of university graduates. Bosnia and Herzegovina has the largest share of graduates in agriculture, forestry, fisheries and veterinary in the total number of graduates (4.73%), while Northern Macedonia has the smallest share (0.96%). In Serbia, the share of graduates in agriculture, forestry, fisheries and veterinary in the total number of university graduates is 2.39% (Figure 1). Considering the fact that in developed countries the share of graduates in agriculture, forestry, fisheries and veterinary in the total number of graduates is about 1% (UIS, 2020), it is concluded that in selected countries of the region the value of this indicator is satisfactory, but that work should be done on better education of students in order to effectively use modern technologies in production to increase the productivity of all inputs used (Dimitrijević, 2022).

Figure 1. Share of graduates in agriculture, forestry, fisheries and veterinary in the total number of university graduates in 2020 (%)

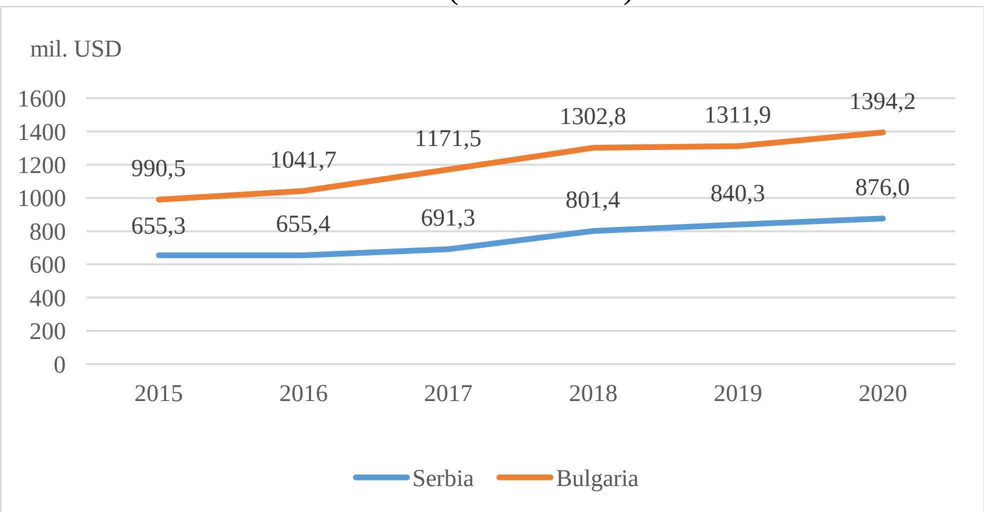


Source: UNESCO Institute for Statistics (UIS)

The second pillar of the GII is Market sophistication, which deals with financial markets, which are important components of any innovation system (Dimitrijević, 2022). One indicator of Market sophistication in the agri-food sector used in this paper is credit to agriculture, forestry and fishing. Due to the specifics of agricultural production, such as seasonality, high risk of the production cycle, and slow capital turnover, credit in agriculture is necessary for most farms to modernize and secure high-quality inputs.

Data on funds provided through credit to agriculture, forestry and fishing are available within the countries of the region, besides Serbia, only for Bulgaria within the countries of the region. From 2015 to 2020, in Serbia, the amount of credit to agriculture, forestry and fishing increased from 655.3 million USD to 876.0 million USD. Although the amount of credit to agriculture, forestry and fishing in our country grows in the observed period, it is significantly lower compared to Bulgaria (Figure 2). The countries with the largest amount of credit intended for agriculture, forestry and fishing (about 70,000 mil. USD) are the United States, France and Australia.

Figure 2. Credit to agriculture, forestry and fishing in the period from 2015 to 2020 (million USD)



Source: FAOstat

Under the third pillar of the GII, which refers to the business sophistication, the indicators adapted to the agri-food sector are the use of mineral fertilizers and the use of mechanization. In conventional agriculture, agrochemicals (mineral fertilizers, protective agents, etc.) are used intensively, which, in addition to the expected positive effects, have many negative and long-term effects on agroecosystems (Kovačević et al., 2011). The uncontrolled use of mineral fertilizers pollutes the basic resources of agricultural production, soil and water, endangering the environment and the health safety of the country. Despite the negative consequences of inappropriate use of mineral fertilizers, an increase in the amount of mineral fertilizers per hectare of arable land was observed in all the observed countries of the region, except Bosna and Herzegovina, from 2015 to 2020 (Table 1). In Serbia, the use of mineral fertilizers per hectare of arable land increased from 99.7 kg/ha in 2015 to 148.5 kg/ha in 2020. According to the 2020 data, the consumption of mineral fertilizers per hectare of arable land was highest in Montenegro and Croatia.

Table 1. Use of mineral fertilizers in the period from 2015 to 2020 (kg/ha)

Year	Serbia	Croatia	B&H	Montenegro	North Macedonia	Bulgaria
2015	99.7	166.9	116.0	165.3	60.5	117.5
2016	129.5	110.0	98.0	178.3	72.4	132.7
2017	111.9	196.3	96.7	147.2	62.9	125.3
2018	67.6	202.8	77.3	155.5	55.4	126.3
2019	110.1	194.3	79.2	151.4	55.8	130.1
2020	148.5	183.4	81.6	190.6	75.4	133.4

Source: USDA

Mechanization has an important role in the process of agricultural production, as agricultural machinery increases labor productivity and reduces operating costs (Vasiljević and Subić, 2005). The indicator - the use of agricultural machinery, expressed in horsepower, includes tractors, combine harvesters, milking machines and water pumps. The data presented show that Serbia has significantly more agricultural machinery compared to selected countries in the region. Although Serbia has more agricultural machinery, the situation of agricultural mechanization in our country is not satisfactory due to the high fragmentation of farms, widely separated plots and insufficient investments. The main problem is the obsolescence of mechanization equipment, as most farms (83%) have tractors older than 20 years (RZS, 2018).

Table 2. Use of mechanization in the period from 2015 to 2020 (in 1000 horsepower)

Year	Serbia	Croatia	B&H	Montenegro	North Macedonia	Bulgaria
2015	16801.9	1250.6	1307.6	5.2	2183.1	2877.5
2016	16979.4	1302.4	1320.3	5.4	2210.9	2948.3
2017	17080,1	2406.4	2208.9	5,6	4364.8	3020.8
2018	17320.5	2655.2	2375.7	5,6	4382.6	3094.7
2019	17652.1	2724.0	2579.5	5.5	4286.0	3187.5
2020	17126.4	2770.1	2091.1	4.9	3716.8	2903.4

Source: USDA

As a measure of the adoption of innovation in the agricultural sector, the following indicators are used under the fourth pillar of the GII - Knowledge and Technology Outcomes: New Varieties of Plant, Gross value added per worker in agriculture and Agri-food exports.

New Varieties of Plant are characterized by better production and technological features, higher yields, high resistance to diseases and pests, and their impact on the environment is minimized, ensuring better plant production (https://www.upov.int/). In order to fully exploit the potential of new plant varieties to increase the productivity of agricultural production, their cultivation must be combined with other modern production technologies. Serbia, as well as all other selected countries in the region, are members of the International Union for the Protection of New Varieties of Plants. However, data for Bosna and Ḫerzegovina, Montenegro and North Macedonia are not available. Compared to Croatia and Bulgaria, our country has a larger number of registered plant varieties, but lags behind the countries with the highest values of this indicator. In 2020, China, the USA and the Netherlands had the highest number of applications for new plant varieties (UPOV, 2021).

Table 3. Number of applications for new plant varieties in the period from 2015 to 2020

Year	**Serbia**	**Croatia**	**Bulgaria**
2015	46	7	16
2016	50	6	35
2017	66	13	48
2018	30	9	18
2019	51	2	25
2020	63	8	26

Source: UPOV

Gross value added (GVA) per worker is essentially an indicator for measuring labor productivity in agriculture. Since there are no data available in the World Bank database for GVA per worker in agriculture only, this paper uses the indicator for GVA per worker in agriculture, forestry, and fisheries. According to the values of this indicator, Montenegro stands out in all observed years, followed by Croatia and Bulgaria. In terms of GVA per worker in agriculture, forestry and fishing, Serbia lags behind all countries in the region, with the exception of BiḪ in 2018 and 2019. All defense regions of the country have lower GVA per worker in agriculture, forestry and fishing compared to the European Union average in 2019 (25475.7

USD). The World Bank publication on the potential of agriculture in the Western Balkans points out that the low value added per worker in the region leads to migration from rural areas to urban areas, as well as to other European countries where agricultural incomes are much higher (World Bank, 2018).

Table 4. GVA per worker in agriculture, forestry and fishing in the period from 2015 to 2019 (USD, 2015)

Year	Serbia	Croatia	B&H	Montenegro	North Macedonia	Bulgaria
2015	5378.9	10209.8	5852.8	19155,2	7722.9	9807.3
2016	5683.1	13145.1	6029.3	19679.4	8080.1	10772.2
2017	5285.2	13735.6	5628.5	18196.0	7080.3	10822.8
2018	6474.3	16052.5	6437.6	18037.6	7733.9	11284.1
2019	6334,2	16127.9	5280.3	19384,2	8282.9	11381.7

Source: World Bank

Surrounding countries have a significant share of the agricultural and food sector in total foreign trade. Compared to neighboring countries, Serbia's foreign trade is characterized by a larger share of the agricultural sector in exports (Table 5).

Table 5. Share of exports of agri-food in total exports in the period from 2015 to 2020 (%)

Year	Serbia	Croatia	B&H	Montenegro	North Macedonia	Bulgaria
2015	21.4	13.6	9.6	18.1	11.9	15.7
2016	21.4	14.4	10.4	16.8	12.1	16.9
2017	18.6	13.6	10.0	13.9	10.7	14.8
2018	17.5	14.1	7.6	12.6	9.3	14.9
2019	18.5	14.4	7.4	12.6	9.7	15.8
2020	21.3	16.0	8.4	14.1	10.2	16.8

Source: UN Comtrade Database

After Serbia, Bulgaria and Montenegro stand out in terms of the share of the agricultural sector in exports, but only in the first years of the analysis. Agricultural products and foodstuffs occupy an important place in Serbia's foreign trade balance, as they generate positive net exports and contribute to the country's overall foreign trade balance. However, the problem is the unfavorable structure of agricultural exports, which are dominated by primary products and products with a lower degree of processing, mainly of plant origin (Božić and Nikolić, 2016). The world's largest exporter of processed agricultural products is the USA, followed by the Netherlands, which, despite being the sixth smallest country in the European Union, occupies the second place in the ranking thanks to the application of modern agricultural technology.

Creative output, which is the fifth pillar of the GII, is expressed for the agri-food sector through the indicators of trademarks and industrial design (Dutta et al., 2017). The protection of intellectual property promotes scientific discoveries and innovations that affect the competitiveness of companies in the market and increase profits and productivity, while reducing costs (Čović et al., 2019).

According to the International Classification of Goods and Services for the Purposes of the Registration of Marks (Nice Classification), classes 29, 30, 31, 32, 33 and 43 are exclusively for agricultural and processed products, and their sum is shown in this paper. However, the identification of classes covering the agro-food sector is complex, as other classes may also contain trademarks related to agriculture and food (Dutta et al., 2017). Bulgaria had the largest number of registered trademarks in the period from 2015 to 2020, which is significantly different from Serbia and other selected countries in the region in terms of the number of registered trademarks. Data for Montenegro are available only for the last three years of the analysis, and based on their values, it represents the country in the region with the lowest number of registered trademarks.

The importance of industrial design is reflected in the increase of product value and thus competitiveness in the market. According to the International Classification of Industrial Design (Locarno Classification), products that constitute industrial design are divided into certain classes and subclasses. Agricultural and food products belong to Class 1, but as in the classification of brands, they are also part of other classes, so the data cannot be extracted only for them. In the period from 2015 to 2020, there were a maximum of 4 design applications for agricultural and food products in Serbia (in 2018), from which it can be concluded that there is not enough interest in our country in the development and protection of designs for these products. Countries in the region also achieve poor results, despite the fact that industrial design is the key strategic factor for any company in the world (Jelisavac-Trošić, 2012).

Table 6. Number of registered trademarks and industrial designs of agri-food products in the period from 2015 to 2020[67]

Year	Serbia		Croatia		B&H	Montenegro	Bulgaria	
	TM	**Ind. design**	**TM**	**Ind. design**	**TM**	**TM**	**TM**	**Ind. design**
2015	2,591	2	4,624	2	386	/	17,919	53
2016	3.138	/	3,928	62	461	/	17.129	264
2017	2,656	1	3.186	1	727	/	12,600	454
2018	4,070	4	3.082	2	821	446	13.001	180
2019	2,746	1	3,664	58	467	436	12,482	33
2020	1.863	1	3,612	1	476	75	14,299	31

Source: WIPO

Conclusion

The study used the Global Innovation Index model, adapted to the agri-food sector, presented in *The Global Innovation Index - Innovation Feeding the World* 2017. Looking at the individual indicators, Serbia achieves the best scores compared to neighboring countries regarding available mechanization resources, number of applications for new plant varieties, and export of agricultural and food products. However, in the above indicators, Serbia lags behind developed countries that are more innovative in agriculture, and improvements are needed in these areas as well. The indicator where our country is significantly worse compared to neighboring countries is the GVA per worker, while it lags behind Bulgaria and Croatia in the number of registered trademarks and designs for agricultural and food products. The area that requires special attention is labor productivity, since according to the GVA per worker indicator, our country is significantly worse off compared to neighboring countries, resulting in a shortage of agricultural labor, a decline in overall productivity, and the abandonment of villages.

[67] Data on the number of trademark applications for agricultural-processing products are not available for North Macedonia, while data on the number of industrial design applications are not available for North Macedonia, B&H and Montenegro.

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Digital Solutions for Agribusiness Development

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Abstract

In the current conditions of sanctions restrictions, the development of the agro-industrial complex and agriculture is impossible without digital solutions that determine the formation of a new technological order in the economy, which is emerging in the context of deglobalization. The article discusses the implementation of an integrated platform for managing the agricultural enterprises.

Key words: digitalization, innovation policy, agribusiness development.

Introduction

Faced with sanctions pressure that began in 2014, the domestic agro-industrial complex received a powerful impetus for development and demonstrated its responsiveness to innovative transformations aimed at activating its potential. The increase in costs for the development of the agro-industrial complex and agriculture (financial, labor, material) in recent years has led to significant results, the industry has become an investment-attractive sector of the economy. However, extensive measures have now practically exhausted themselves [4].

For the industry to effectively solve its problems, an innovative breakthrough is needed to implement the import substitution policy at all stages of the technological process aimed at ensuring the food security of our country. All the variety of measures that contribute to the achievement of food security as the main target for the development of the agro-industrial complex and agriculture, the constituent elements that are interconnected with each other, should be part of an innovative "in spirit" and content

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strategy. The implementation of an innovative strategy for ensuring the food security of the Russian Federation should become a means of developing a new technological order in which the national ecosystem will be provided with its own resources, knowledge and experience [6]. At the present stage, we should talk about the organization of innovation activities in the context of the implementation of the import substitution policy aimed at solving the food problem with the help of domestic players [9].

Agricultural enterprises in Russia and the region are involved in digitalization processes, since the competitiveness of the Russian agro-industrial complex in modern conditions depends on new technologies [3]. Since 2019, the Russian Ministry of Agriculture has been implementing the Digital Agriculture project. He assumes that by 2024 a platform will start working in the country that will include data on agricultural resources (for example, on agricultural land, livestock numbers, availability of agricultural equipment) - this is necessary for planning and predicting risks. According to this project, 50 % of industry professionals should learn how to work with digital products and technologies [1].

The most notable positive shift has occurred in the digital transformation of agriculture. In 2021, companies in the industry began to use ERP systems 1.5 times more often (6.7 % vs. 4.5 % in 2020). The demand for electronic document management systems has grown from 41.4 % to 49.7 %, technologies for collecting, processing and analyzing big data, artificial intelligence and industrial robots - by more than a third. The current level of development of digital technologies has made it possible to automate a significant part of agricultural operations, significantly reducing the amount of manual labor [8]. This was partly due to systemic measures of state support, concessional lending and good economic performance of the industry. In the foreseeable future, new generation communication technologies will make it possible to monitor irrigation systems, animal care, and control equipment in real time [5].

Material and Method

The level of digitalization in the agro-industrial complex in Russia and the region is diverse, it clearly reflects the diversity of the agricultural sector, since large agricultural holdings are at a fairly high level of digitalization and robotization. On the other hand, there are many small farms in the country that cannot afford the large-scale use of digital technologies.

Modern business practice requires, as a rule, an individual approach. This fully applies to accounting and planning. Therefore, the most effective software is adapted directly to the complex tasks of a particular enterprise. The cost of such development is quite high due to the individual approach and implementation features, but, as a rule, the economic effect justifies the costs.

In modern conditions, without the introduction of digital technologies, it is difficult to withstand the competition of agricultural products. This direction faces a number of problems. One of them can be called a shortage of personnel in this area. Agricultural universities train graduates in information areas, but these personnel are not enough, and, as calculations show, at least 90,000 specialists need to be trained for the country's digital agriculture [2].

The Russian integrated platform for managing agribusiness "Agroanalytics-IoT" helps to fully automate planning, monitoring the implementation and analysis of the results of field work. To date, this is the only system that allows you to control up to 2/3 of the factors that affect the increase in yield, reduce costs and production costs while improving its quality. "Agroanalytics-IoT" provides up to 80 % of the management needs of a modern agricultural enterprise. The "Agroanalytics-IoT" server collects and analyzes indicators of satellite monitoring and a variety of sensors, processes data using intermediate calculation algorithms, which reduces the system load by an order of magnitude during complex calculations. The potential expansion of the system's functionality through partner development makes its possibilities practically unlimited.

Information sources of "Agroanalytics-IoT" are: systems of satellite monitoring of transport; filming from unmanned aerial vehicles; satellite remote sensing systems; sensors on machinery; weather stations; soil sensors; sensors in warehouses and other storage areas; agricultural enterprise files; accounting and ERP systems; data from third-party companies (reference information databases and advisory support).

Functionality in agronomy includes - automatic detection of the type of technological operation performed; monitoring the implementation of agricultural work in real time; automatic calculation of the cultivated area; determination of the quality of field work; forecasting yield; control of the movement of the crop from the field to the weight; automated formation of waybills; automatic calculation of wages.

The program has a Master of Confirmation of the Consumption of Materials. It helps to accurately and timely reflect the consumption of materials for the work performed: automatically calculates the amount of materials used based on the actual amount of work performed in hectares. Based on technological maps or templates, selects the composition of materials. Supports loading data with calculations from Excel files or accounting system.

An agronomist makes decisions based on a lot of data to get a good harvest and reasonable resource savings. This is information about the condition and characteristics of soils, weather, cultivated crops, seed quality, vegetation dynamics, applied technologies, fertilizers and plant protection products – so far more than 40 sources for making informed decisions, including the history and crop rotation of the enterprise for any number of years. "Agroanalytics-IoT" helps to quickly collect and process this information to make decisions on the competent cultivation of soil and plants, which helps to increase profit per hectare by 10 %. The register of fields contains basic information about fields, allows to check their actual and accounting area, displays information about the state crops and biomass development index.

Field passport contains following data - satellite imagery and drone survey data; cadastral information with discrepancy view; field ranking by yield; list of planned works on the field with the ability to create production tasks; NDVI snapshots and analysis of biomass development dynamics; task cards for differentiated application; data from agrochemical surveys; field map with sampling points and observations of agroscouting; weather data and weather history; other required information.

To draw up a financial plan, cost centers are used, with the help of which you can conduct general and detailed financial planning by months. After confirming the completion of work and the consumption of materials, a cost log is formed: "Agroanalytics-IoT" automatically calculates the amount of expenses for each item, taking into account the prices for materials and work. Data on cost items by direction and production purpose (fertilizers, seeds, fuels and lubricants) can be transferred to the ERP system for accounting and financial analysis. Field costs are collected in the dashboard "Summary field expenses". In the "Agroanalytics-IoT" system analytical reports on the consumption of materials and the cost of carrying out technological operations, maintenance of equipment, wages are available.

The dashboard shows the dynamics of costs by crop and its yield in order to choose the most effective strategy for growing crops with reasonable savings. resources of the agricultural enterprise. "Agroanalytics-IoT" shows not only the planned cost structure, but also data on the profitability of growing a crop, an assessment of the expected employment of equipment and consumption of materials, and analytics on growing options (plan-fact).

The lag of the agricultural sector in informatization is due to the specifics of the agricultural industry, which is focused mainly on traditional information processing technologies, the level of development of the digital communications infrastructure in the countryside, as well as the lower incomes of the country's rural population relative to the urban population. In such a largest agricultural holding in the region as Helio-Pax-Agro LLC, only 5 % of the fields are digitized. However, even medium and small agricultural enterprises are also introducing digital technologies into production. In the digital technology market, there is a wide range of platforms for use in agribusiness. One of these solutions is the Agroanalytics platform. The system is capable of collecting and analyzing dozens of parameters using information sources from satellite monitoring systems to third-party data. "Agroanalytics-IoT" frees the employees of the agricultural enterprise from monotonous work, as it helps to fully automate planning, monitoring the implementation and analysis of the results of field work [7].

Today, agricultural analytics allows you to fully automate the processes of planning, monitoring the implementation and analysis of field work, as it controls the full cycle of agricultural work.

The advantages of using analytical systems in the work of an agricultural enterprise are:

- increase in productivity;
- improving the quality of products;
- cost reduction;
- reducing the cost of the product;
- timely receipt of up-to-date information and making the right management decisions.

The sources of information for the operation of the Agroanalytics platform are transport monitoring, weather stations, unmanned aerial vehicles, sensors, cameras, satellite, agricultural enterprise files, ERP systems.

Functionality: control of the vegetative state and development of plants; cadastral control; cost accounting for fields and equipment; meteorological control.

The system allows to determine the type of technological operations, control the execution of technological operations, control the movement of crops from the field to the weight, automatic calculation of wages, forecasting yields thanks to the artificial intelligence system, automated generation of waybills [8].

The program includes the implementation of an ERP system. This is a resource management and planning system, a program that contains all the information about the company's business processes and orders. It synchronizes the activities of different departments of the enterprise. The main goal of ERP is the collection, structuring of information, automation of processes, as well as high-quality accounting of resources. The system allows to automate, along with the main and auxiliary processes (tax, cadastral registration) [9].

The implementation of the Agroanalytics system is being tested at the Bykovo-Agrotrans LLC enterprise.

According to the estimates of enterprises that have already implemented this system, the following results have been achieved:

- reduction of production cost up to 15 %;
- reduction of crop losses up to 40 %;
- reduction of expenses on fuel and lubricants up to 30 %;
- reduction of processing time for waybills up to 90 %;
- yield increase up to 10 %.

We have calculated the economic effect from the introduction of the Agroanalytics system. The effect is calculated on 1000 hectares and amounted to 3.5 million rubles. The system makes it possible to increase the efficiency of the use of the land fund by identifying unused plots, clarifying the boundaries of fields, controlling the completeness of processing, reducing the risk of loss of land and crops on leased lands. An increase in the intensity of the use of equipment is achieved by reducing downtime, planning and timely maintenance of all agricultural units.

The process of selling products must be built on a single end-to-end platform for the promotion and sale of agricultural products, the creation of which is devoted to the works of many scientists [10].

Conclusion

"Agroanalytics-IoT" helps agricultural specialists to take into account current resources, production capacities, historical data on fields and yields, crop rotation and other factors when drawing up a plan for a year, a season or several days. Annual (seasonal) planning includes the production and financial program for the development of the enterprise for the next year (season). Annual planning helps to calculate costs and assess the needs of the agricultural enterprise, determine their KPI based on the results of the work, analyze the influence of various factors on productivity and make decisions on the need for adjustments in crop growing technologies, the list of materials and equipment used. On the basis of the annual plan, operational plans for 1-10 days and shift tasks are formed with the appointment of equipment, personnel, taking into account weather conditions and the condition of plants.

The implementation of the digital scenario for an economic entity requires taking into account all its socio-economic, technical, territorial and other features; having direct contacts with scientific institutions. Often agricultural enterprises are not ready to implement digital processes in economic activities due to the lack of financial opportunities, staffing, digital competencies of managers and a clear vision of the digital future of companies.

The problem of food security can be solved as a result of the development of an innovative strategy for the development of the agro-industrial complex, which makes it possible to level the challenges of deglobalization as a new institutional order and ensure the effective implementation of the import substitution policy aimed at achieving technological sovereignty.

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Determination of the Dependence Between the Number of Advisors and the Number of Contacts with Agricultural Producers in PSSS Jagodina

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Abstract

This work aims to determine whether increasing the number of advisers increases the number of contacts with agricultural producers, thereby increasing the number of producers to whom information is transmitted in the field by PSSS. PSSS Jagodina doo was taken as a sample for this research, wherein the period from 2014 to 2020, the number of advisors was increased from 8 to 12, that is, by 4 new advisors. Based on the results obtained by calculation in the SPSS package, it can be concluded that there is a statistically significant correlation at the level of $P<0.01$, that the correlation is positive, high, and amounts to 0.933. The results of the correlation analysis show that the degree (strength) of dependence is extremely high between the number of advisers as an independent and the number of contacts as a dependent characteristic.

Key words: counseling, rural development, agriculture, farms

Introduction

The socio-political, economic, and structural changes that Serbia is going through in the long-term transition process have a significant impact both on the entire economy and on agriculture, which is the potential of Serbian society. The sustainability and development of Serbian agricultural and rural sectors are in every respect threatened by globalization and modernization, and the problem of weak competitiveness of Serbian

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agriculture is dominant. Agricultural consultancy is one of the important factors in the development, modernization, and strengthening of the competitiveness of agriculture, especially in the transition and globalization period that Serbian agriculture faces (Janković, Petrović, 2010). The priority of advisory work and activities is to increase the competitiveness of agricultural production and train farmers to be more successful in agricultural production and farm management, through transfer of and state agricultural policy measures.

Agricultural consultancy is one of the important factors in the development, modernization, and strengthening of the competitiveness of agriculture, especially in the transition and globalization period that Serbian agriculture faces (Janković, Petrović, 2010). Without investment and agricultural consultancy in various ways, the agriculture of developing and transition countries cannot develop, regardless of the farming and rural policy measures taken (Janković, Petrović, 2007). The term regression analysis refers to a set of statistical procedures for examining the form of dependence between two or more characteristics. Regression analysis can also be defined as an assessment of the value of the dependent variable based on one or more independent variables. The subject of correlation analysis is determining the degree of qualitative agreement of variable variations (Stanković et al., 2002). Print determining the effects of advisory work in agriculture, through the calculation of gross margins of dominant lines of products using multiple regression methods and analysis of regression coefficients, the percentage of dependence of gross margin as a dependent variable to changes in independent variables (yield, price and variable costs) was determined. The overall analysis resulted in an assessment of the effects of advisory work in different production lines (Filipović, 2019).

Without investment in agricultural consultancy, development of research in agriculture, and education of advisers and agricultural producers, the agriculture of developing and transition countries cannot get out of the "vicious circle" of underdevelopment with all the measures of agrarian and rural policy (Petrović and Janković, 2007). The basic legal regulation for the performance of advisory services in agriculture throughout the territory of the RS is the "Law on the Performance of Advisory and Expert Services in the Field of Agriculture", which was adopted in 2010 and defines advisory and professional services, as well as their goal.

The medium-term and annual programs for the development of advisory services in agriculture further predict and prescribe a certain increase in the number of licensed advisors. A greater number of advisers has the effect of increasing fundsfrom the budget that must be set aside for those purposes, which otherwise stands as a question of the justification of the costs of advisory work. If it is assumed that one of the most significant effects of advisory work is the access and transmission of information about a larger number of agricultural producers, then the research in this work can provide results that can justify the increase in the number of advisors, and thus the budget funds that have been invested.

The goal of the work was to determine that an increase in the number of advisors increases the number of contacts with agricultural producers, thereby increasing the number of producers to whom information is transmitted in the field by PSSS.

Material and method of operation

Agricultural counseling is one of the important factors in the development, modernization, and strengthening of the competitiveness of agriculture. The following data were used in the work:

Sources of data: internal documentation of PSSS Jagodina d.o.o., a database of IPN's realized advisory work, and legislation of the Republic of Serbia related to agriculture and agricultural advisory services, according to the author of domestic literature.

Location: agricultural advisory service Jagodina-PSSS Jagodina from Jagodina.

Statistics: Descriptive statistics methods were used to collect, arrange and display numerical data and quadratic regression and correlation methods to determine the degree and form of dependence between the number of advisers and the number of contacts with agricultural producers.

Data collection: 22 PSSS operate in the territory of central RS, where the number of counselors increased by 32 from 175 to 207 licensed counselors in the period from 2014 to 2020. PSSS Jagodina d.o.o. was taken as a sample for this research, wherein the period from 2014 to 2020, the number of counselors increased from 8 to 12, that is, by 4 new counselors.

Table 1. Number of contacts made (individual activities)

Farming	Agricultural activity	Year							Total
		2014	2015	2016	2017	2018	2019	2020	
Selected	Selected advice given on the farm	895	725	779	1046	1212	1258	1348	7263
	Advice given in service	18	0	9	41	14	19	24	125
	Advice given over the phone	1	0	0	15	9	9	26	60
	Tip sent by email	0	0	0	0	2	0	1	3
Total		914	725	788	1102	1237	1286	1399	7451
Rest	Selected advice given on the farm	662	589	683	834	1002	1001	1068	5839
	Advice given in service	257	103	55	844	763	797	552	3371
	Advice given over the phone	18	0	0	407	396	406	558	1785
	Tip sent by email	0	0	0	1	2	2	3	8
Total		937	692	738	2086	2163	2206	2181	11003

Source: IPN database

The area of activity of PSSS Jagodina is the Pomeranian district, which consists of the city of Jagodina and the municipalities of Paraćin, Svilajnac, Ćuprija, Despotovac, and Rekovac and includes 186 inhabited places and close to 16,000 registered agricultural farms. Data on the number of advisers and the number of contacts with agricultural producers were obtained from the internal documentation of PSSS Jagodina doo and the database of IPN, an organization authorized to monitor and evaluate advisory work.Advisory work is divided into individual and group activities through which advisors come into direct contact with agricultural producers - users of services, based on which the relevant research is carried out. Advisory work includes both written and media activities, for which it is not possible to adequately determine the exact number of contacts with readers, listeners, and viewers.

Table 2. Number of contacts made (group activities)

Activity	Year							
	2014	2015	2016	2017	2018	2019	2020	Ukupno
Lecture	411	341	617	775	964	860	659	4627
Workshop	366	298	441	219	251	242	185	2002
Winter school	116	145	123	117	119	120	120	860
Tribune	111	156	550	730	595	497	456	3095
Tour of the farm	49	47	54	86	96	108	90	530
Ukupno	1053	987	1785	1927	2025	1827	1510	11114

Source: IPN database

It is evident from the table that in most cases the advisers believe that they are sufficiently motivated to properly cooperate, contact and thus apply advice through the application of modern technology in production, while other forms of communication represent a traditionalist approach and insufficient knowledge of such productions.

Based on the data from Tables 1 and 2, table 3 was created.

In accordance with the subject and objective of the work, in order to determine the dependence between the number of advisors and the number of contacts made with agricultural producers who participate in advisory activities, the quadratic regression and correlation method was used.

Results and Discussion

In accordance with the subject and goal of the research, and through the chosen method of quadratic regression and correlation, the following research results were obtained.

Table 3. Coefficients obtained by regression analysis

	Unstandardized coefficients		Standardized coefficients	T	Statistical significance
	B	Standard error	Beta		
Number of counselors	5293,787	1861,744	7,048	2,843	,047
Number of counselors ** 2	-230,478	92,960	-6,145	-2,479	,068
A constant	-25066,961	9110,400		-2,751	,051

Source: Authors

The chosen regression model for analysis is adequate, the value of the F test is statistically very significant, $P<0.01$, which confirms that the number of counselors as an independent variable predicts the number of contacts as a dependent variable. The number of advisors has a very significant effect on the number of contacts made, and the result of the regression analysis explains 93% of the total variance. As an indicator of variability, the standard deviation is mostly used. The standard deviation is the square root of the mean square of the deviation of the feature value from the arithmetic mean. It shows how close the clustered feature values are around the arithmetic mean. In the observed 7 years, that value for the observed number of advisors is approximately 2, and for the number of contacts made, approximately 1301.

Table 4. Indicators of the results of descriptive statistical measures

	Aritmetička sredina	Standardna devijacija	Medijana	Modus	Koeficijent asimetričnosti α_3	Koeficijent spljoštenosti α_4
Kontakti	4230.429	1300.997	5.090	2.404	0.000	-0,5055
Broj savetodavaca	10.000	1.732	10.000	8.000	-1,978	-2,196

Source: Authors

The form of distribution implies two characteristics, namely asymmetry, and flatness. The observed distribution for the number of contacts is very weakly asymmetric because $\alpha_3 = 0$, and for the number of advisers the distribution is left asymmetric because $\alpha_3 = -1.978$. With the number of contacts, according to the flattening coefficient where $\alpha_4 = -0.5055 < 3$, the schedule is very flattened (platykurtic).

Table 5. Indicators of quadratic regression analysis for the number of advisers and the number of contacts

	Zbir kvadrata	Stepeni slobode	Srednji kvadrat	F test	Statistički značaj
Regresija	9474108,255	2	4737054,128	27,806	,005
Ostatak	681449,459	4	170362,365		
Zbir	10155557,714	6			

Source: Authors

The schedule with the number of advisers where $\alpha_4 = -2, 196$ is also flattened. Based on the results obtained by calculation in the SPSS package, it can be concluded that there is a statistically significant correlation at the level of $P<0.01$, that the correlation is positive, high, and amounts to 0.933.

Table 6. Prikaz rezultata korelacije

R	R^2	Prilagođeni koeficijent determinacije	Standardna greška procene
,966	,933	,899	412,750

Source: Authors

The results of the correlation analysis show that the degree (strength) of dependence is extremely high between the number of advisers as an independent and the number of contacts as a dependent characteristic. The chosen regression model for analysis is adequate, the value of the F test is statistically very significant, $P<0.01$, which confirms that the number of counselors as an independent variable predicts the number of contacts as a dependent variable. The number of advisors has a very significant effect on the number of contacts made, and the result of the regression analysis explains 93% of the total variance.

Conclusion

Based on the presented research results, using the statistical method - of quadratic regression and correlation, it can be concluded that there is a statistically significantly positive, high correlation of 0.933 between the number of advisers and the number of contacts with agricultural producers.

The obtained regression coefficient, which is 0.93, confirms that the number of counselors has a very significant effect on the number of contacts made and explains 93% of the total variance. Starting from the subject, goal, and problem of the research, based on the results, it can be concluded that an increase in the number of advisors increases the number of contacts with agricultural producers, which is one of the goals of advisory work in agriculture. At the same time, it can be stated that the financial resources from the budget were justifiably spent on that basis. Deviations from the one hundred percent dependence of the number of contacts made about the number of counselors can be explained by the different numbers and types of activities in the observed years. The Program for 2017 included modules from different fields of agriculture, as a new activity, which increased the number of activities per adviser, and thus the number of contacts with producers. The factor that affects the observed issue is the very structure of the advisors, that is, from which field of agriculture the advisor is. In 2019, PSSS Jagodina employed an advisor from the field of plant protection who, according to the program, does not entrust his farm leaders, but follows the entrusted farms of advisors from other fields of agriculture. For these reasons, there was no marked increase in the number of contacts with producers in that year. For 2020, there is a noticeable decrease in the number of contacts, primarily within group activities, due to the outbreak of the pandemic and the impossibility of gathering a large number of producers.

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Family Farms in ANC – to Innovate or to Leave the Sector?[73]

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Abstract

The aim of this paper is to examine how different farm characteristics influence the potential of farms in an area with natural constraints in Serbia to innovate. To determine both inter- and intra-relationships between the selected characteristics by examining the proximity and distance between the variables, the method of Multiple Correspondence Analysis was employed. The research results showed that the innovation potential of family farms is closely related to the determination of farm succession, farm holder education, the use of farm investment support and insurance premium subsidy, as well as farmers' plans to apply for rural development measures in the future.

Key words: innovations, family farms, multiple correspondence analysis, areas with natural constraints, Serbia

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Introduction

The increasing demands for food as well as the need to reduce the negative impact of agriculture on the environment are putting pressure on the agricultural sector to produce more with less input. Concepts such as "Smart Agriculture", “Precision Agriculture”, "Agriculture 4.0." and the like are seen as promising solutions to this complex challenge facing the food system. These new advanced 4IR agriculture technologies (sensors, drones, blockchains etc.), help to reduce costs, improve quality and traceability of agricultural and food products, and increase yields. However, all this cannot ignore the challenges of adoption, not only those related to available infrastructure, the capacity of the machinery and equipment industry, the need for new actors and new roles, but also the challenges on the side of farmers (European Commission, 2017; Fuetsch, 2022).

Innovations are often associated with numerous risks that can hinder their implementation. These risks include the excessive complexity of new processes and practices that require specific knowledge, lack of financial resources, ownership/succession issues, and market conditions. In addition to these risks, family farms, especially smallholders and farmers in remote areas, face particular barriers to accessing innovation, such as difficult access to resources, markets, knowledge, and information.

Diederen et al. (2003) found that farm characteristics such as size, market position, age, and solvency explain the difference in farmer adaptation to innovation. Läpple et al. (2015) conclude that farm size and intensity, access to credit, and agricultural education foster innovation while increasing age and working off-farm hinder farm innovation. Research conducted by Bremmer et al. (2002) showed that there is no relationship between age, succession, farm income, and farm renewal (innovation and diversification). Arzeni et al. (2021) consider public support as an important financial lever to encourage business investments and highlights the importance of tailoring innovation support to farmers' needs (mostly through European Rural Development Policy).

The purpose of this paper is to examine the extent to which selected characteristics of farms and their managers influence their willingness to innovate their resources and farming practices over the next 3-5 years. The research focuses on farms in areas with natural constraints to agricultural production (ANC), which are given special support to invest in new equipment, machinery, and facilities due to their development constraints.

Material and methods

The research was conducted on a sample of 370 family farms from mountain areas of Eastern and Southern Serbia (Table 1). Data were collocated trough face-to-face interviews during July-August 2018 (Papić, 2021).

Table 1. The names of the municipalities with the number of settlements and the number of respondents included in the sample

Municipality	Number of settlements	Number of respondents
Bor	2	53
Majdanpek	3	12
Boljevac	8	39
Knjaževac	9	42
Sokobanja	11	43
Babušnica	19	63
Bela Palanka	9	19
Pirot	26	76
Dimitrovgrad	7	24
		Total = 371[77]

Source: Illustration by the authors

The research recognizes that farm innovation is a complex process influenced by numerous factors. Therefore, to find out how farm characteristics influences farmers' tendencies to innovate, the analysis includes the next seven variables: farmers' plans to invest on farm and utilization of rural development support, farmers' experience with rural development measures supporting farm innovation, farm specialization, household income, and farm successor (Table 2). In addition, socio-demographic variables such as farmers' age, gender, and education were included as supplementary variables in order to understand how respondent profile impact farmers' affinity to innovate (Table 3). Given that all variables in the research are categorical and the analysis options are limited, Multiple Correspondence Analysis (MCA) using the Burt matrix method (Greenacre, 2007) was chosen as an appropriate statistical approach. MCA, using $\chi2$-distance, allows the assessment of associations and dependencies between individuals and categorical variables by representing them in a low-

[77] One farm was excluded from the sample because the survey data were incomplete, so the analyzes were performed on a total of 370 farms.

dimensional space, i.e., a map in which similar objects are grouped as a cloud of points. MCA has been widely applied in various studies (Parchomenko et al., 2019, Greenacre and Blasius, 2006; Husson and Josse 2014; Bucalo Jelić, 2021, etc.), including those focused on rural areas (Fantappiè et al., 2020; Garcia-Arias et al., 2015; Nedanov and Žutnić, 2018; Ozden and Mendes, 2005, etc.). MCA analysis was performed using R version 4.02.

Table 2. Main variables

Variable descriptions	Categories (labels)
Plan to invest in the next 3-5 years	Definitely not (INV_1)
	Unlikely (INV_2)
	Not sure (INV_3)
	Very likely (INV_4)
	Definitely yes (INV_5)
Plan to apply for rural development support in next 3-5 years	Definitely not (PRS_1)
	Unlikely (PRS_2)
	Not sure (PRS_3)
	Very likely (PSD_4)
	Definitely yes (PRS_5)
In the last 3 years farmer have applied for the on-farm investments support	Yes (OFI_1)
	No (OFI_2)
In the last 3 years farmer have applied for insurance premium subsidy	Yes (IP_1)
	No (IP_2)
Identified successor	Unlikely (S_1)
	Not sure (S_2)
	Very likely (S_3)
	Definitely yes (S_4)
	Unlikely (S_5)
Main household income	Agriculture (HI_1)
	Salaries (HI_2)
	Pensions and social benefits (HI_3)
	Remittances (HI_4)
Main farm income	Sale of plant products (FI_1)
	Sale of animal products (FI_2)
	Sale of plant processed products (FI_3)
	Sale of animal processed products (FI_4)
	Sale of wood (FI_5)
	Others (rural tourism, services by mechanization, renting of land, etc.) (FI_6)

Source: Illustration by authors based on survey

Table 3. Supplementary variables

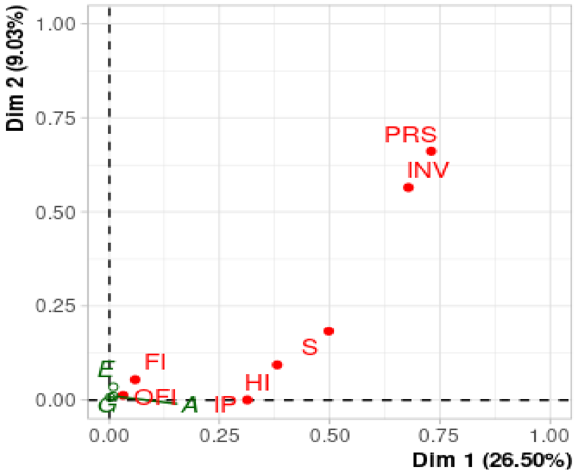
Variable descriptions	Categories (labels)
Gender of farm holder	Male (G_1)
	Female (G_0)
Age (years) of farm holder	Under 40 (A_1)
	More than 40 (A_2)
Education of farm holder	Primary education (E_1)
	Secondary education (E_2)
	College (E_3)
	University (E_4)

Source: Illustration by authors based on survey

Results

The MCA analysis detects that the variables in the data set can be effectively represented in a low-dimensional space consisting of 22 dimensions. The absolute values of inertia indicate the degree of separation of the categories along the dimensions, with the greatest separation observed in the first two dimensions (0.148 and 0.050). The relative values of inertia (26.5% and 9.0%) indicate that the two-dimensional map accurately represents the data with 35.5% accuracy. The graphical results of the MCA analysis, shown in Figure 1 and Figure 2, visually illustrate the interrelationships among the relevant variables.

Figure 1. Correlation between variables and first two principal dimensions



Source: Authors' data processing using R.

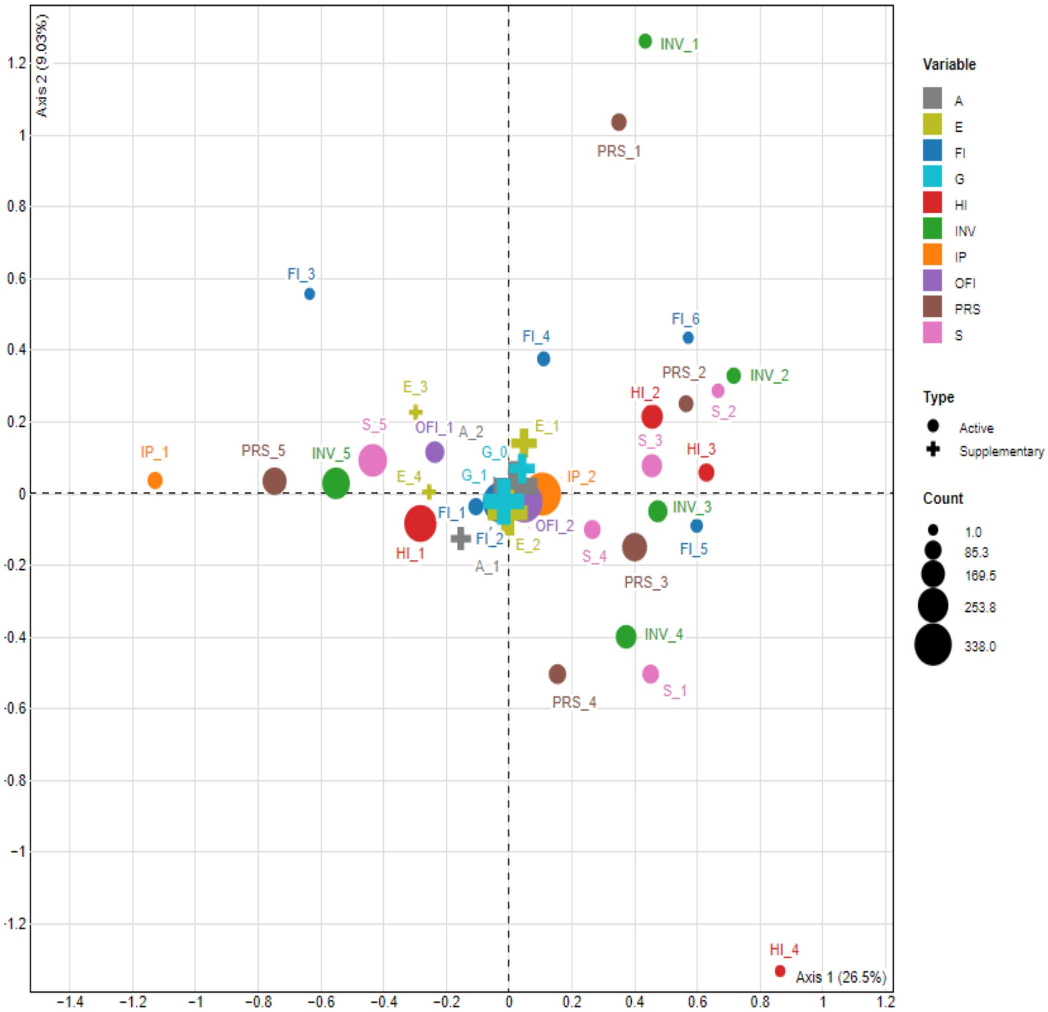
In Figure 1, the variables are represented as points, and the position of each point on the first and second axes corresponds to the squared correlations of the variables with these axes (Husson and Josse, 2014). A high squared correlation indicates a clear separation of the different categories of variables along this axis. This is observed for variables representing farmers' plans to invest in the next 3- 5 years (INV) and farmers' plans to apply for rural development support (PRS). Conversely, a squared correlation close to 0 suggests that the variable does not exhibit clear separation along this axis. This is the case for the variables representing farmers' experiences in the process of applying for on-farm support (OFI) and farm income (FI).

The primary result of the MCA analysis is the map in Figure 2, where the *x*-axis and *y*-axis correspond to the first and second dimensions, respectively. The arrangement and proximity of the points on the map are determined by the $\chi 2$-distance and indicate the relationships and associations among categories. The origin of the MCA map represents the average, while the distance of a category from the origin signifies its deviation from the average. The size of the dots in the map is proportional to the proportion of respondents in each category.

The variable (INV) divides the MCA map into two categories along the *x*-axis. Farmers who plan to invest in their farms in the next 3-5 years (such as purchasing new machines, equipment, or constructing buildings) are represented on the left side of the *x*-axis (INV _5), while those who are less certain of their investment plans (INV _1, INV _2, INV _3, INV _4) are located on the right side of the *x*-axis (Figure 2).

The farms with the highest innovative potential (INV_5) are characterized by holders who have identified a future successor (S_5), are relatively younger (A_1), and possess strong entrepreneurial skills. They also have higher levels of education (E_3; E_4), better access to information, and a deeper understanding of available support measures. As a result, they participated in on-farm investment schemes and insurance premium programs (OFI_5; IP_1). Furthermore, they express a strong intention to apply for rural development support in the future (PRS_5). In this plot agriculture is the primary income source of the households (H_1). Läpple et al. (2015) highlight that farmers with higher levels of education are more effective in processing new information, leading to increased awareness of available innovations.

Figure 2. MCA map for the main and supplement categories



Source: Authors' data processing using R.

On the other hand, farms with lower innovative potential (located on the right side of the map) exhibit distinct characteristics that reflect conservative and rigid management structures. Namely, these farms have not yet determined a farm successor, indicating a lack of long-term planning. The farm holders are older than 40 years (A_2) and have primary or secondary education (E_1; E_2). They have not used on-farm investment support or insurance premium subsidies, and do not plan to do so in the future. Pensions (HI_3) and salaries from the formal sector (H_2) are the main sources of household income for this group. Consequently, this group is characterized by wide range of farms with different socio-economic statuses, among which are elderly/single farms and farms whose younger members are employed in the public sector. Läpple et al. (2015) also found that increasing age of farmers and engaging in off-farm jobs are barriers to farm innovation.

Conclusion

The analysis shows that the greatest propensity to innovate is among farms whose main income comes from agriculture and where owners are assumed to have better entrepreneurial skills because they are younger than 40 years and have a higher level of education.

In contrast, farms whose main income comes from pensions or non-farm activities have lower innovation potential. Low levels of education, older farm owners, and the fact that their income from farming is secondary affect their interest in investing in modern technologies and practices, but may also affect the potential to acquire new knowledge.

All of this suggests that a combination of interventions is needed to meet the diverse needs of the heterogeneous livelihood strategies of family farms in ANC. A number of policy recommendations can therefore be derived from this empirical analysis, particularly those that promote sustainable agriculture in ANC through different types of innovations.

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The Income of Small Family Farms in South Banat Area Focused on Agricultural Production[78]

Mihajlo MUNĆAN[79], Jelena ĐOKOVIĆ[80], Tamara PAUNOVIĆ[81]

Abstract

Most of agricultural production in Republic of Serbia is organized on family farms. However, their number is decreasing.

Based on data collected on 15 family farms located in the South Banat area, focused exclusively on crop production, income was examined as farm owner's basic motivation for further development of agricultural production on small farms. Using a method of calculations of the gross margin, as well as fixed costs and subsidy amounts that the farms received in the observed ten-year period, it was determined that the income alone does not provide sufficient motivation. In fact, the average income realized on family farms is almost 30% lower than the average income realized in the observed area.

Also, due to low realized incomes, family farms will not be able to secure funds for investments in digitalizing and automating of sustainable production, which represent the basic principles of Agenda 4.0.

Key words: family farms, crop production, income

[78] The work is the result of research within the framework of the "Agreement on the implementation and financing of scientific research in 2023 between the Ministry of Science, Technological Development and Innovation of the Republic of Serbia and the University of Belgrade Faculty of Agriculture, contract registration number: 451-03-47/2023-01/200116.

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Introduction

Based on numerous researches, published publications as well as statistical data, it can be stated that the Republic of Serbia is one of the countries with a dominant share of crop production in the total agricultural production. This is supported by the fact that in the structure of the total agricultural production, crop production accounts for over 65% (Munćan et al., 2014), while about 82% of the 3.3 million hectares of arable land was used for crop production. Family farms own about 80% of agricultural land, 86% of cultivated land, 84% of arable land, as well as 97% of the total number of tractors. Family farms participate in corn production with 88%, in wheat production with 73%, in sunflower production with 65% and about 50% of sugar beet and soybeans production (Božić, Munćan, 2007).

However, significant participation of small family farms in the total number of farms, the low level of agricultural technology, outdated machinery and the negligible percentage of irrigated areas have a strong impact on the economic results of these farms (Munćan, 2016). Most of agricultural production in the Republic of Serbia is realized on family farms in AP Vojvodina (Munćan et al. 2010; Todorović, 2018). On average, 52% of the total area under cereals and over 92% of the total area under industrial crops in the Republic of Serbia is cultivated in this region (Bošnjak, Rodić, 2010).

What can pose a threat to the overall development of agriculture in the Republic of Serbia is the reduction in the number of farms, especially small ones. According to the results of the survey conducted in 2018, about 564 thousand farms were registered in the Republic of Serbia, of which 99% or nearly 562 thousand were family farms. Namely, between the census of 2012 and the survey conducted in 2018, there was a significant decrease in the number of households by almost 10%, i.e. by almost 60 thousand expressed in absolute numbers. There are numerous reasons for the reduction (Pejanovic et al. 2013, Jankovic & Novakov, 2012), but one of the most important is the absence of economic motives for the farm holder.

The success of agricultural production depends, on the one hand, on the realized yields and sales prices, and on the other hand, on the incurred costs (Munćan, 2011). However, in addition to the financial results achieved by production itself, government benefits realized through subsidies, premiums, etc., can have a significant impact on the realization of income.

For the stated reasons, and with taking into account the importance of family farms for their available resources, engaged workforce and used land, the subject of research in this study was family farms and their incomes. Based on the data of 15 surveyed commercial farms, the trend of economic results over a period of 10 years was examined and economic indicators were calculated. The realized income, as one of the main economic indicators, was compared with the average realized income in the region in order to determine the profitability of organizing agricultural production.

Research methods and data source

The main source of data for this research was a survey conducted on 15 small family farms, focused exclusively on crop production, located in South Banat.

The selection of farms located in South Banat stems from the fact that South Banat is one of the most important areas for crop production in the Republic of Serbia (Munćan, 2016), because in addition to favorable natural conditions, this area is also characterized by:

- the largest participation in the structure of used agricultural and arable land,
- the largest number of commercial farms with 10-100 ha of land,
- the largest share in the sowing structure of basic agricultural crops (wheat, corn, sunflower, soy, sugar beet), and
- the largest share in the production of wheat, corn and sunflower, etc.

The selection of surveyed farm was carried out in accordance with the objective of the study and was based on the fact that farms up to 20 ha meet the conditions for achieving incentives for plant production (Regulation on financial support to agricultural farms for the agricultural production of plant crops in 2023, Article 3. Paragraph 2.), which represents an additional possibility for increasing the income of family farms.

Therefore, the basic criteria for choosing a farm were arable land and location. In this study, based on collected data, a research was conducted with the aim of determining the income as the basic revenue for employees in agriculture. Calculations of the gross margin, as well as fixed costs and subsidy amounts that the farms received in the observed ten-year period, were made for the observed farms.

The determined average income of the observed farms per active member was compared with the average income in the region, with adequate following conclusions.

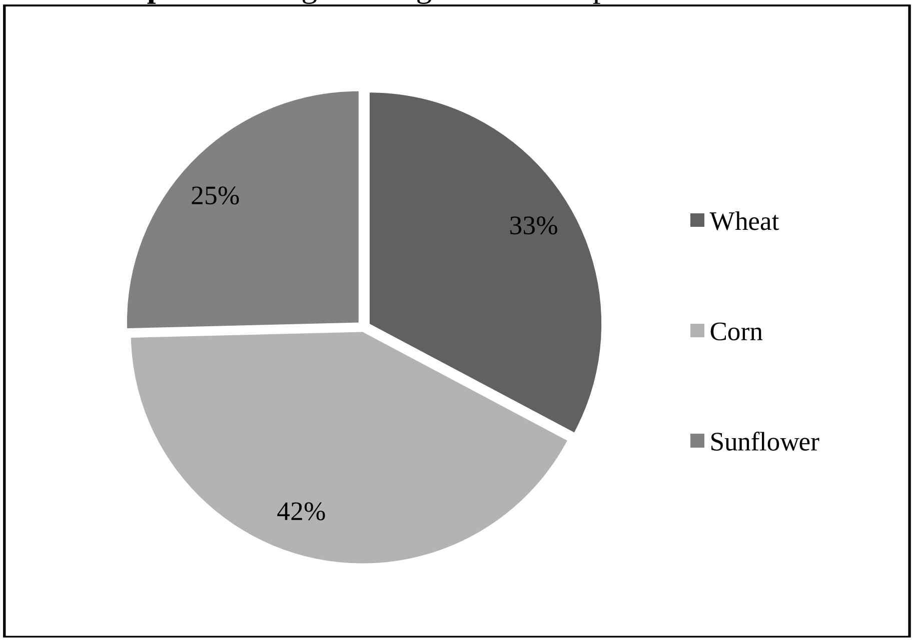
Research results

Basic characteristics of the farms observed

The following data were collected on the surveyed farms: arable land, available mechanization, applied agrotechnics and production technology, production structure, realized yields, realized selling prices, used inputs (seeds, mineral fertilizers, herbicides, diesel fuel), purchase prices of used inputs, etc.

The analyzed farms have an average of 15.3 ha of arable land, which they use exclusively for commercial crop production. In accordance with natural and soil conditions, all farms organize a three-field crop rotation with wheat, corn and sunflower (Graph 1).

Graph 1. Average sowing structure in period 2013-2022



Source: Author's calculation based on the data collected

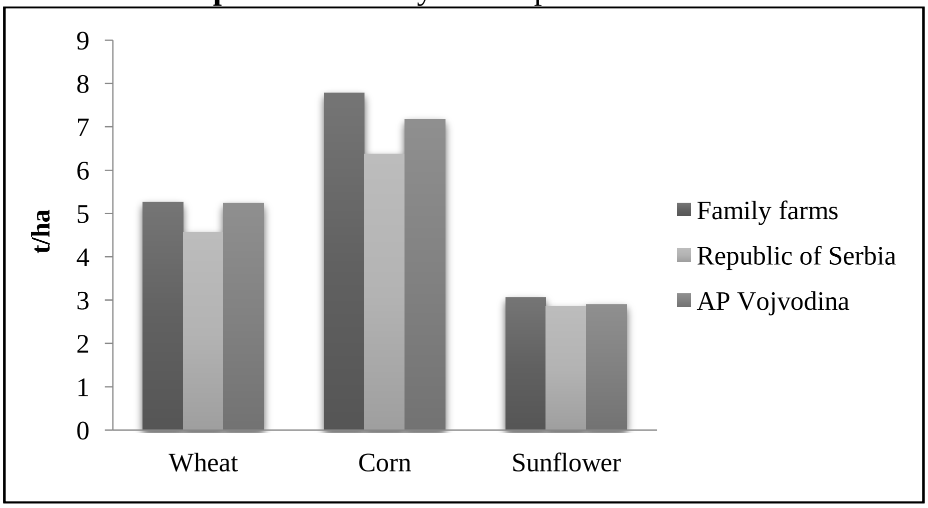
Surveyed farms do not grow soybeans, due to unfavorable climatic conditions for cultivation in the micro location, while sugar beet is not grown due to unfavorable organizational and market conditions.

On six of the observed farms, two members generate income directly from the farm, that is, averages of 1.4 farm members are active in crop production. The surveyed farms have an average of 1.6 tractors optimally aggregated with all necessary attachment machines.

The production technology is well organized, taking into account the positioning of the agricultural land and the available mechanization.

Considering the analyzed organizational aspects, available resources and production technology, it can be stated that farms achieve good yields of cultivated crops, which are above the national and around the regional average (Graph 2).

Graph. 2. Realized yields in period 2013- 2022

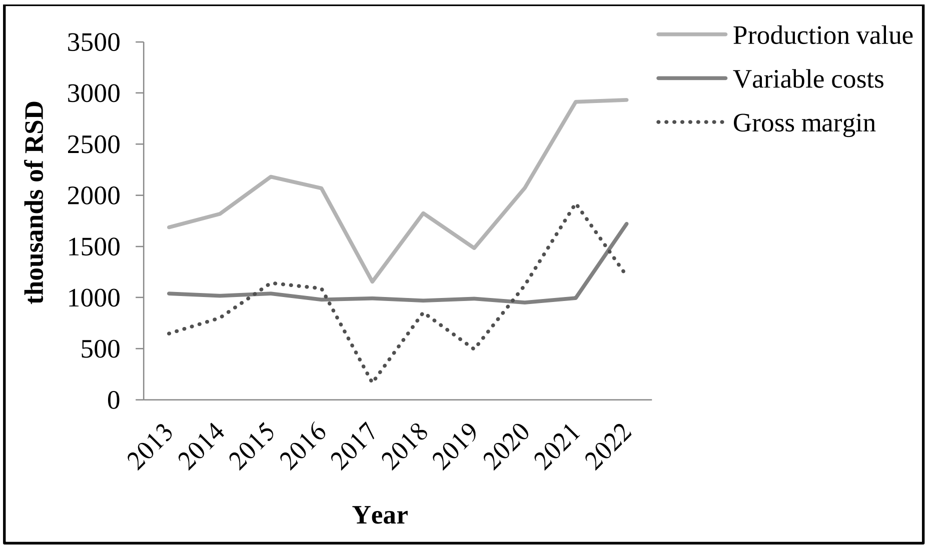


Source: Author's calculation based on the data collected and the database of the Statistical Office of the Republic of Serbia

Business results of the surveyed farms

As the basic production success indicator of the observed farms, gross margin was calculated as a difference between the realized production value and total variable costs (Ivkov, et al. 2008). It determines how much agricultural producers gain or lose from the invested funds. Based on production results and direct variable costs on the observed farms, the average gross margin was calculated (Graph 3).

Graph. 3. Gross margin in period 2013-2022



Source: Author's calculation based on the data collected

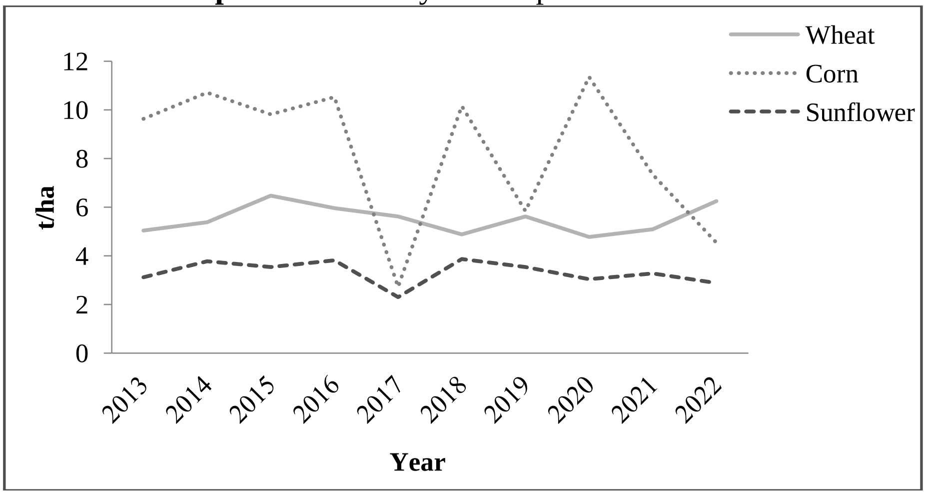
Additionally, the gross margin provides foundation for continuous business monitoring and the base of product competitiveness and the improvement of profitability, both for the applied production type and a farm as a whole.

Based on Graph 3, it can be concluded that the amount of variable production costs on the observed farms is uniform during the entire ten-year period, except for the last year, 2022, when a significant increase in costs occurred due to increased prices of inputs, primarily mineral fertilizers and fuel.

The average realized gross margin is primarily determined by the volume of realized yields, namely corn, which are directly influenced by natural conditions, especially drought. The lowest value of the gross margin was realized in 2017, which in the observed period was the most unfavorable year for crop production, when sunflower yields were about 30% lower than average and corn yields were lower for even 70%. In 2017, corn production had a negative average gross margin, which caused a loss on most farms, because achieved average yields were only 2.43t/ha (Graph 4).

Also, in 2019 and 2022, farms achieved lower yields in corn production, while wheat and sunflower yields were constant throughout the observed period.

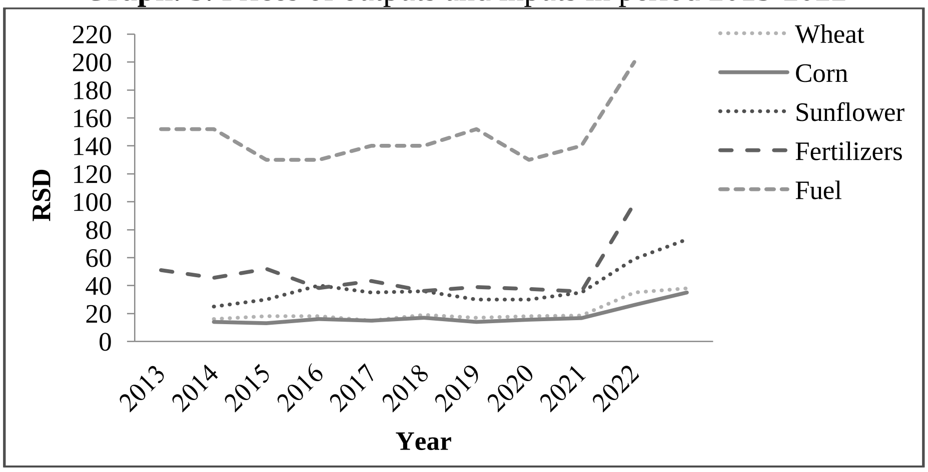
Graph. 4. Realized yields in period 2013-2022



Source: Author's calculation based on data collected

Alongside yield volume, the prices of both inputs and products have a major impact on achieved results. Also, in the observed period, prices did not have significant oscillations, except in the last two years, when there were drastic price changes. In the last two years, the prices of all products have increased by almost 70%, while in 2022 alone, the prices of inputs, especially mineral fertilizers, have increased by around 110% (Chart 5).

Graph. 5. Prices of outputs and inputs in period 2013-2022



Source: Author's calculation based on data collected

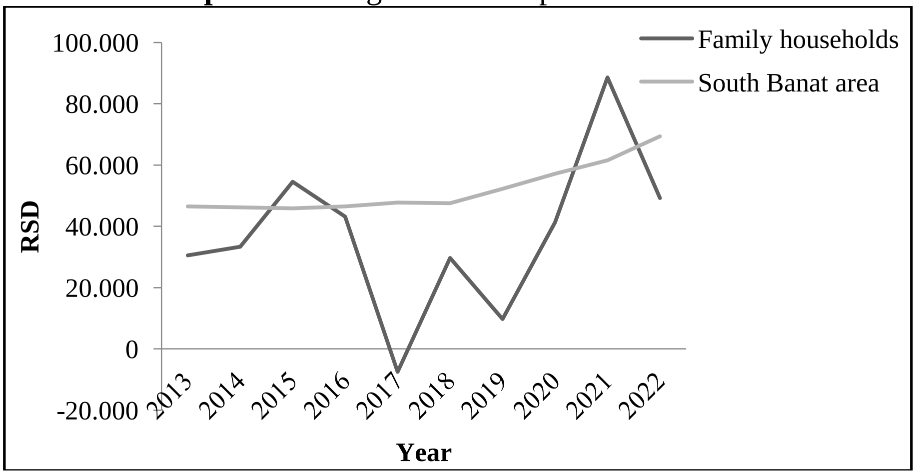
Income of the observed farms

After the analysis of the achieved gross margin, which in the calculation contains only variable costs, it is necessary to analyze the income of the observed farm, because it includes both variable and fixed costs, including the tax on cadastral income (i.e. property tax), drainage fees, social, health and pension insurance (Gogić, 2009).

Beside mentioned fixed costs, the costs of crop insurance and mechanization maintenance should also be included, while interest and depreciation costs do not exist, due to self-financing of production and the age of machines and facilities.

Based on the calculated gross margins, as well as fixed costs and received subsidies, the income per active member of the farm was determined. The calculated income was then compared with the average earnings in the South Banat area, where farms are located, in order to examine the economic justification of organizing crop production (Graph 6.)

Graph. 6. Average income in period 2013-2022



Source: Author's calculation based on data collected

Based on the calculation of monthly earnings, it can be stated that family farms earn almost 30% lower monthly earnings than average employee earnings in the South Banat area. If the subsidies that farms receive are discarded, then the wages of employees on farms are as much as 43% less compared to employees in the area. In only two of the observed ten years, 2015 and 2021, farm employees earned wages higher than the farm average.

Conclusion

Based research results, it can be concluded that without adequate government aid, there are very few economic motives for engaging in agriculture on small farms. Average earnings on farms, which are almost 30% lower than the average earnings in the observed area, indicate that, alongside wide range of factors that influence migration from villages to cities, the economic motive is one of the most important. For this reason, active farm members are forced to earn their income outside of agriculture for existential reasons.

After all, family farms will not be able to secure sufficient resources for sustainable production, especially in field of digitalizing and automating, and by that achieve the goals of Agenda 4.0.

A higher amount of direct benefits (subsidy, premium...), more favorable conditions and subsidized loans for the purchase of modern mechanization or land could represent the path that the government should follow in order to stop the negative trends of leaving rural areas but also to ensure constant stability in food production.

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Profitability and Investments of EU Specialized Crop Farms – Are They Related Over Time?[82]

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Abstract

While farms specialized in field crop production are the most numerous in the EU, cereals, oilseeds and protein crops (COP) farms are the most common within them. Therefore, COP farms sized 50,000-100,000 EUR (expressed in standard output) were used to observe trends of number of farms, profitability and investment activity over time. Cross-correlation methodology was applied to analyze correlation between time series of indicators expressing profitability and investment activity. To acquire the data needed for the analysis authors used FADN public database for period from 2004 to 2020. The results indicated that changes in profitability indicator (Return of Equity) are associated with investment activity (Gross Investment on Fixed Assets and Net Investment on Fixed Assets) one year later. Having in mind that the correlation is positive and strong, the results could be used for making appropriate policy measures as well as to reach informed business decisions on farm level.

Key words: COP farms, ROE, investments, FADN, cross-correlation.

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Introduction

To analyze performance of the European Union (EU) farms authors can use Farm Accountancy Data Network (FADN) database as reliable source of data. FADN database covers variety of farm types and sizes giving an insight in their economic and other characteristics. There are some recent research dealing with farm profitability on the base of FADN data – they intended to discuss the best way of expressing farm profitability (applying indicators such as Return on Assets – ROA or Return on Equity – ROE), while trying to determine factors which influence profitability the most (Kryszak et al., 2021; Vukoje et al., 2022). Literature review performed by Garzon Delvaux et al. (2020) presented how profit is related to analysis of farm size (expressed in hectares). Boggia et al. (2023) discussed farm profitability as an element of estimation of its sustainability (profitability is considered to be one of the economic indicators). Describing economic dimension indicators of sustainability based on FADN data Wilczyński (2020) suggested number of profitability indicators. Svoboda et al. (2020) analyzed agriculture in the EU countries for period from 2004 to 2017 (using FADN data) concluding that during that period farms increased their profit due to production increase.

At the same time, other research based on FADN data discussed importance and level of gross and net investments. Ivanović et al. (2020) compared investment activity (and investment subsidies) of Serbian farms to investments of farms in neighboring countries – Croatia, Hungary, Romania and Bulgaria (applying FADN methodology). Firlej and Kubala (2021) used Analysis of Variance (ANOVA) approach and FADN methodology to discuss the hypothesis that level of investments of agricultural enterprises is related to their production type.

On the other hand, a cross-correlation analysis can be useful for gaining insight into the relationship between two indicators over time (cross-correlation tracks the similarities in the movement of two indicators over time). Bošnjak et al. (2013) applied cross-correlation approach to „perceive the lag effects of average annual purchase prices on the harvested areas of soybean in Serbia”. The concept of cross-correlation is also used in economics for analysis of real estate issues (Zhang et al., 2021), Bitcoin market (Ma et al., 2022), exchange rates (Zhao and Chui, 2021), energy prices (Duda and Augustynek, 2005), technological innovations (Ke et al., 2023), prediction of financial crisis (Zheng et al., 2012), and other economic topics (Araujo, 2011). It is also common to apply cross-correlation methodology to address certain issues which could be related to agricultural production, such as modeling of surface water – groundwater interaction (Posavec et al., 2017) and analysis of hydrometeological data (Ružić et al., 2016).

Having above mentioned in mind, the goal of this research is to determine cross-correlation between profitability of specialized COP (cereals, oilseeds and protein crops) farms with economic size between 50,000 and 100,000 EUR in the EU and their level of investments activity (on the base of FADN data). Therefore, the research question is – are annual average ROE and Gross Investment on Fixed Assets (GIoFA) as well as ROE and Net Investment on Fixed Assets (NIoFA) for this type and economic size of farms in the EU correlated with each other over time?

Material and method

This research uses a subset of data from the FADN database, while the data cover period from 2004 to 2020 (due to the fact that year 2004 is the first year in which standard output is applied). Values of two variables are taken directly from the FADN database:

- (SE516) Gross Investment on Fixed Assets (GIoFA) in the EU in a given year (expressed annually in EUR) and
- (SE521) Net Investment on Fixed Assets (NIoFA) in the EU in a given year (also expressed annually in EUR).

As a third indicator (expressing level of farm profitability) authors applied ROE, which is calculated using approach given by Vukoje et al. (2022). According to these authors ROE is calculated as the ratio of (SE420) Farm Net Income and (SE501) Net Worth.

While correlation indicates how closely two variables are related in a statistical sense, "cross-correlation function extends the concept of correlation to the timing of two indicators" (Backus et al., 2017). To perform the cross-correlation analysis authors used R software environment.

Results and discussion

The focus of this paper is on specialized crop farms. When it comes to farm types, is necessary to consider that farms (in accordance with FADN methodology) could be divided in two ways, i.e., there could be 8 or 14 types of farming. When performing this analysis authors focused on more detailed farm division by types (14 types of farms) discussing specialist COP farms. The analysis deals with this farm type because such farms prevailed (16.35%) in the EU in 2020 (comparing to other specialized or mixed farm types) (table 1).

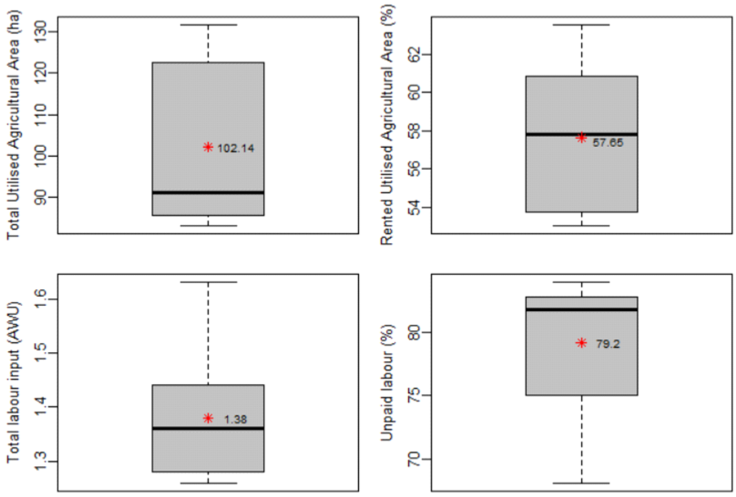
Table 1. Share of different farm types represented by FADN in the EU

<table>
<tr><th colspan="2">Farm types</th><th colspan="2">Share of different farm types (%)</th></tr>
<tr><th>8 types</th><th>14 types</th><th>8 types</th><th>14 types</th></tr>
<tr><td rowspan="3">(1) Fieldcrops</td><td>(15) Specialist COP</td><td rowspan="3">31.37</td><td>16.35</td></tr>
<tr><td>(16) Specialist other fieldcrops</td><td>10.32</td></tr>
<tr><td>(60) Mixed crops</td><td>4.70</td></tr>
<tr><td>(2) Horticulture</td><td>(20) Specialist horticulture</td><td>3.48</td><td>3.48</td></tr>
<tr><td>(3) Wine</td><td>(35) Specialist wine</td><td>5.66</td><td>5.66</td></tr>
<tr><td rowspan="3">(4) Other permanent crops</td><td>(36) Specialist orchards - fruits</td><td rowspan="3">13.51</td><td>6.53</td></tr>
<tr><td>(37) Specialist olives</td><td>4.50</td></tr>
<tr><td>(38) Permanent crops combined</td><td>2.49</td></tr>
<tr><td>(5) Milk</td><td>(45) Specialist milk</td><td>10.81</td><td>10.81</td></tr>
<tr><td rowspan="2">(6) Other grazing livestock</td><td>(48) Specialist sheep and goats</td><td rowspan="2">16.14</td><td>7.64</td></tr>
<tr><td>(49) Specialist cattle</td><td>8.50</td></tr>
<tr><td>(7) Granivores</td><td>(50) Specialist granivores</td><td>2.79</td><td>2.79</td></tr>
<tr><td rowspan="2">(8) Mixed</td><td>(70) Mixed livestock</td><td rowspan="2">16.25</td><td>2.01</td></tr>
<tr><td>(80) Mixed crops and livestock</td><td>14.25</td></tr>
</table>

Source: Authors calculations based on FADN public database, 2020

When it comes to farm size, in FADN methodology it is expressed by farms economic size (various levels of standard output). In this analysis authors discussed specialized COP farms with economic size between 50,000 and 100,000 EUR. The data from period 2004-2020 indicate that farms of this size cultivate in average 102.14 hectares (graph 1). However, utilized agricultural area (UAA) varied considerably across analyzed period, ranging from 83.29 ha per farm (in year 2015) to 131.47 ha per farm in year 2007 (a negative trend from 2007 should be highlighted). More than half of utilized agricultural area on the analyzed farms was rented (57.65 %). Total labor input per farm expressed by number of Annual Work Units (AWU) is 1.38. However the average labor input varied across years, ranging from 1.26 AWU per farm (in year 2020) to 1.63 AWU (in year 2007). As expected, a significant part of the labor force employed on analyzed farms (79.2%) is family labor (unpaid labor).

Graph 1. Labor and UAA of analyzed farms in period 2004-2020

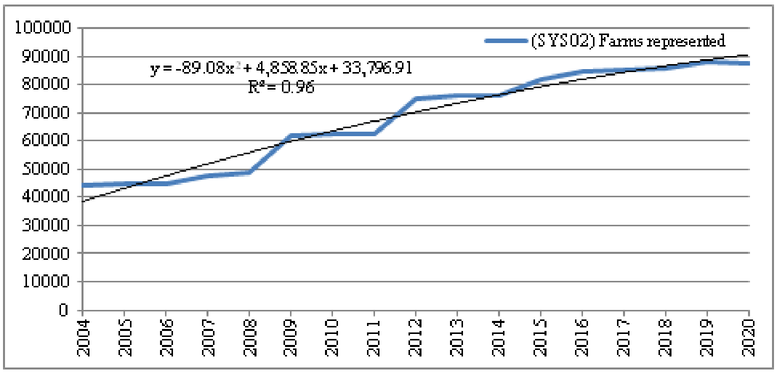


Note: * denotes the mean value of the indicators

Source: Authors calculations based on FADN public database

Analysis of number of farms represented by an appropriate FADN sample (graph 2) reveals increasing trends i.e., from year 2004 to 2020 number of observed farms (COP farms which have economic size between 50,000 and 100,000 EUR) almost doubled.

Graph 2. Trend of number of analyzed farms in period 2004-2020

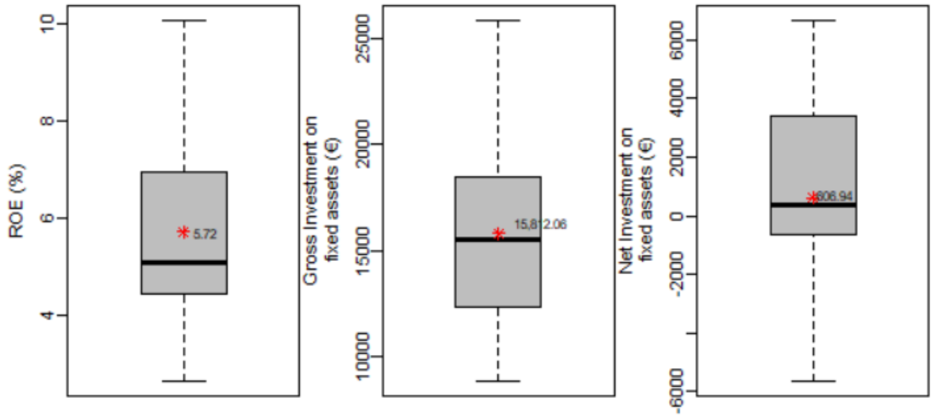


Source: Authors calculations based on FADN public database

When it comes to economic indicators of farm activity (graph 3) an average annual ROE in analyzed period range from low (2.65% in year

2009) to high (10.07% in year 2007), with a mean of 5.72%. Average annual GIoFA in analyzed period ranged from 8,844.00 EUR (in year 2016) to (25,855.00 EUR) in year 2008, with a mean of 15,812.06 EUR. During the same period average annual NIoFA fluctuated from -5,645.00 EUR (in 2006) to 6,672.00 EUR (in 2008), while mean value was 606.94 EUR.

Graph 3. Economic indicators of analyzed farms in period 2004-2020



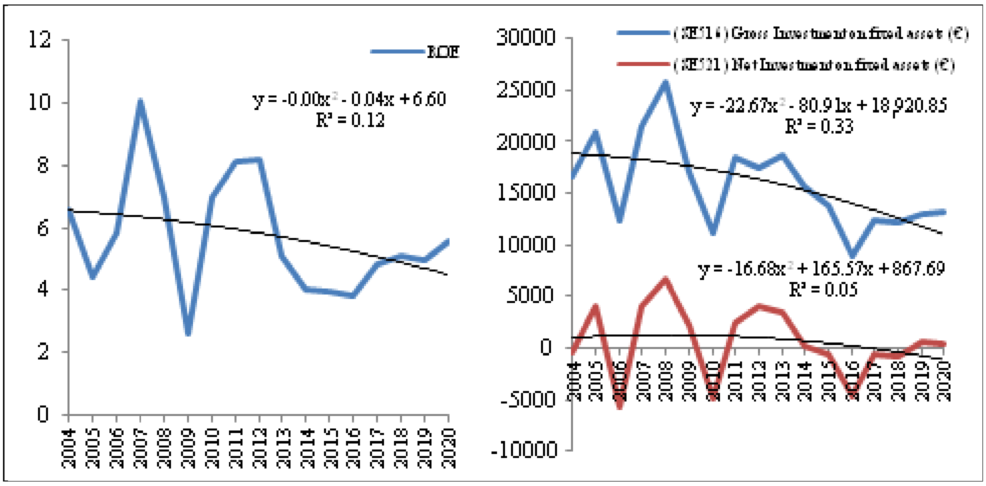
Note: * denotes the mean value of the indicators

Source: Authors calculations based on FADN public database

Comparison of specialized COP farms of observed economic size with an average in the EU (average of all farm types and sizes in the EU during observed period) indicates that analyzed farms are not in favorable position. An average ROE in the EU is higher than in the analyzed sample (it is 7.00%) while the same is noticeable for NIoFA (the EU average is 669 EUR per farm). Only an average GIoFA in the EU is lower (9,718 EUR) comparing to analyzed group of farms. Besides, an average ROE in the EU expressed lower level of variability comparing to analyzed farms (it fluctuated from 5.41% to 8.23%), indicating higher level of riskiness related to economic performance of farms in question.

Although number of such farms grows, the opposite trends could be noticed when it comes to farm profitability and investments activity (graph 4). The results indicate that number of farms of certain size and production type is not dependant on their ability to create profit or on their investment activities. It could be also noticed that GIoFA is more volatile than NIoFA, but they follow each other (as it was expected).

Graph 4. Trend of ROE, GIoFA and NIoFA of analyzed farms in period 2004-2020



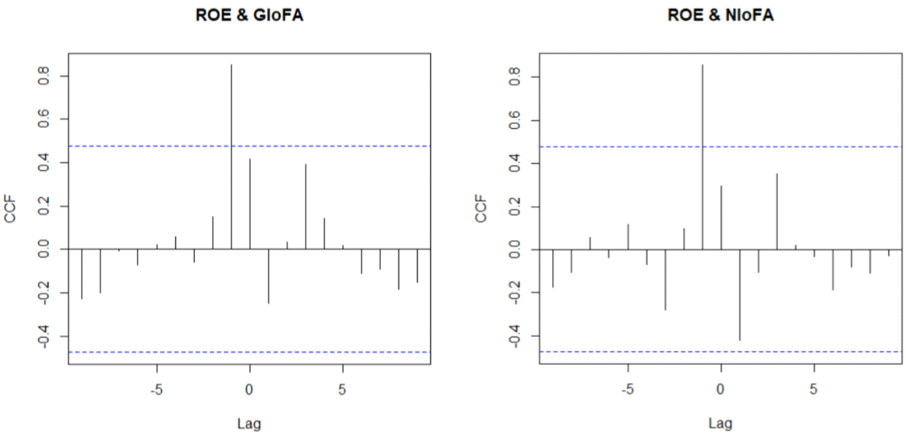
Source: Authors calculations based on FADN public database

Decreasing trend of farm investment activity could cause slower introduction of modern technical and technological solutions in production process. It could be noticed that net investments on fixed assets are negative in many years, which in essence leads to shrinking of farm production capacities.

Having in mind that fluctuations and trends of ROE, GIoFA and NIoFA are similar, it is possible to analyze whether there is correlation between ROE and GIoFA as well as ROE and NIoFA over time. Therefore, authors examined cross-correlation between these time series (graph 5). Graph 5 shows that the strongest correlation between two time series doesn't occur at lag 0. The correlation at lag 0 (contemporaneous correlation) equals 0.418 (for ROE and GIoFA) and 0.297 (for ROE and NIoFA). This shows that ROE and GIoFA as well as ROE and NIoFA are positively correlated at lag 0 and that correlation is weak (not significant).

However, graph 5 does show a positive correlation (the highest correlation overall) at lag -1 between ROE and GIoFA as well as ROE and NIoFA. Therefore, this cross-correlation function could be described as procyclical. The correlation equals 0.850 (for ROE and GIoFA) and 0.856 (for ROE and NIoFA) and in both cases could be defined as strong.

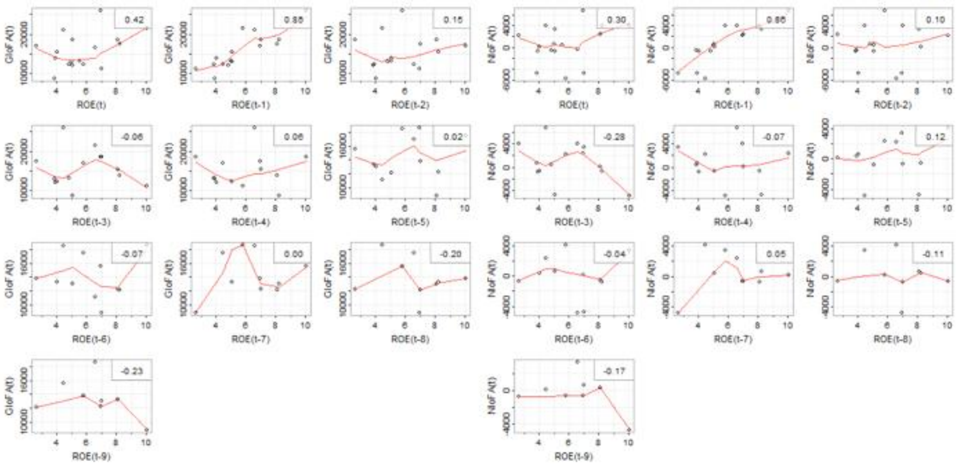
Graph 5. Cross-correlation between ROE and GIoFA as well as ROE and NIoFA



Source: Authors’ calculation

This suggests that increase in ROE at a given point in time precedes increase in GIoFA and NIoFA by one year. In other words, higher than average ROE tends to lead to higher than average GIoFA and NIoFA one year later. At the same time, there is no statistically significant correlation at other lags between ROE and GIoFA as well as ROE and NIoFA. Details of correlation for periods preceding moment t=0 are presented on graph 6.

Graph 6. Correlation of ROE and GIoFA as well as ROE and NIoFA (period t=0 to t-9)



Source: Authors’ calculation

Both detailed graphs (for ROE and GIoFA as well as ROE and NIoFA) indicate that correlation coefficients before period t=-1 (the highest lag being -9) are low and not statistically significant (while the majority of them is even negative).

Conclusion

The analysis revealed that specialized EU COP farms of observed economic size (which cultivate approximately 100 hectares of land) have negative trends of profitability and investments level. This compromises their ability of adopting innovative technical and technological solutions and leads to questionable long term perspectives of such farms. It was also determined that ROE of the analyzed farms is lower than the EU average, expressing higher volatility at the same time. Understanding whether ROE is correlated with specific investment indicators (GIoFA or NIoFA) and, if so, whether one leads or follows the other could help policy makers, farmers, and economists make better business decisions.

The analysis revealed that ROE is leading indicator since the cross-correlation function peaks with a lead of one year. In such a way ROE indicates future movements of GIoFA and NIoFA. Knowing which factors influence ROE (and in what way they influence ROE) could offer better insight in understanding of future investment activities of the farms. Therefore, future research should be directed towards cross-correlation of ROE and variables which affect profitability the most.

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Production and Economic Aspects of Vegetable Production in the Republic of Serbia[85]

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Abstract

Vegetable production is a highly intensive branch of agriculture. The basic preconditions of a successful vegetable production, both in an open field and in a greenhouse lie in optimal use of inputs and the integration of all o rganisational and technological activities. The research focuses on a detailed analysis of production process and effects of technological, economic and organisational factors on the contribution margin. Using calculation and statistical methods, the authors analysed the effect of the total area under crops (ha), the method, type, system and technology of production, the method of seedlings procurement, seedlings production, the representation of irrigation systems, the representation of crop feeding systems, the number of production cycles in a year, the elevation, the aspect (of plot/s) and the type of soil on the contribution margin. The total area, production system, irrigation and feeding systems, as well as the method of seedlings procurement are the main parameters affecting the contribution margin.

Key words: vegetable, technology of production, economic indicators, contribution margin.

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Introduction

The Republic of Serbia is one of the key regional producer of vegetables. Vegetable production in Serbia in 2021 and 2022 was carried out on about 120,000 ha (RBS). The quality of inputs, primarily seeds and fertilizers, is directly correlated to competitiveness of vegetable production. Vegetable production is of great importance for Serbian agriculture in general, having great potential for development in predominantly vegetable-growing areas. From the aspect of yields, net profit and labour productivity in agriculture, vegetable production is one of the most intense branches of plant production, amounting to 5 to 8 times higher value of production than wheat in open field and 190 to 250 times higher in greenhouse production (*Vlahović et al., 2010*). Quality seedlings are required for successful vegetable production both in open field and greenhouse production. However, there is almost no quality domestic seeding material available (*Moravčević, 2015*). Demand is met by imports, due to generally undeveloped domestic market and poor levels of production of quality propagation material (*Ilin et al., 2002*). *Ivanišević et al. 2018* analysed tomato production depending on the method of procurement of seedlings, by calculating economic parameters of tomato production when propagating your own seedlings and when purchasing them on the market. When producing 800 tomato seedlings from 1,000 seeds, the total cost amounted to RSD 16,387.26, resulting in price cost of RSD 20.5. Purchase price was 19.24 RSD/kg. In both analysed cases, seedling costs were dominant in the structure of total costs, whereby the production in both cases was economical and profitable. *Gvozdenović et al. (2006)* in their paper described the technology of propagating seedlings in thermal containers and their further growing in open fields. Very significant piece of information is the one of the cost of pepper seedlings production amounting to RSD 0.15 per seedling. *Červenski et al. (2009)* analysed the propagation of seedlings for late cabbage production (cold beds).

Vegetable crops are grown in almost all regions of Serbia. Depending on agroecological conditions, such production can be done in open fields or in greenhouses, yet open field production prevails. Vegetable production is rather intensive, primarily due to the fact the soil can be used multiple times during a production year (two to three different crops can be grown per year), as well as feeding and irrigation systems. Such production results in high yields and high profits per unit area, which is on the other hand in correlation with intensive labour. In the period 2007-2018, total value of production of agricultural products and services averaged 504.4 billon RSD, whereas the total value of vegetable production in 2018 averaged 39.3 billion RSD. In 2018, the vegetable sector on average made up 7.79% of the total agricultural sector. According to the Statistical Office of the Republic of Serbia, vegetable production in Serbia is done on 120,000 ha (ten-year average), making up 3.5% of the total arable areas. Nevertheless, areas under vegetable crops have been declining, primarily due to a shortage of labour, since labour is a determining factor for conducting and expanding this type of production. Given the areas under vegetable crops, the Republic of Serbia is 67th producer in the world and 10th producer in Europe. The most common vegetable crops in Serbia are the potato, tomato, pepper, melon and watermelon, cucumber, cabbage and kale. The increase in vegetable production in Serbia has been higher than in other countries in the region and in all observed group of countries, while the total production of vegetable has been at the average level of new EU member countries (*Ljiljanić, 2022*).

The methods used in this research are in line with the subject and the goal of the research. The analysis of the contents (*White and March, 2006*; *Weber, 1990*) was used in reviewing relevant domestic and international references in terms of technology, structure of production and characteristics of products. The authors used the methods of descriptive statistics for primary and secondary data, as well as the correlation analysis. As for calculation method, the authors used the analytic calculation of incomplete costs (net income, contribution margin, gross margin) (*Gogić, 2009; Dabbert and Braun, 2012*). The data were collected from 282 farms that predominately produce vegetables in the Rasina, Jablanica and Mačva districts. The data were retrieved from software (online application) "Technological & economic matrices of plant production" of the Institute for Science Application in Agriculture. Apart from those data, the Institute for Science Application in Agriculture also collect data from the sample that comprises 1,250 farms whose predominant type of production is not vegetable production. These online matrices comprise basic data on areas under vegetable and varieties, data on applied production technology and on cost of material, cost of production in terms of direct costs. Moreover, scientific and vocational papers were used to provide insight into modern technological processes applied worldwide and wider understanding of the subject of the research.

Results and discussion

The total sample of 282 farms were taken to perceived production and economic parameters of main vegetable crops in the Republic of Serbia: tomato, pepper, cucumber and cabbage. The following traits were analysed: total area under crops (ha), method of production, type of production, system of production, technology, method of procurement of seedlings, share of irrigation system, share of plant feeding systems, number of production systems in a year, elevation, aspect (of plot/s) and type of soil. Descriptive statistics was used to distribute the sample by key parameters. According to representation of certain production systems, the cucumber and pepper are primarily grown in an open field.

Table 1 shows the total contribution margin per area unit for each individual vegetable crop, and Table 2 shows the total area under a certain vegetable crop, whereas most areas, on average, are under cabbage and least under tomatoes.

Table 1. Contribution margin given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean
Cucumber G	30	218.020,00	10.027.950,00	3.550.902,07
Cabbage O	17	204.533,33	2.883.340,00	1.098.177,36
Pepper O	73	307.500,00	6.926.625,00	2.149.623,56
Pepper G	37	216.500,00	9.308.966,67	3.476.965,48
Tomato O	16	396.250,00	7.824.060,00	2.855.224,58
Tomato G	105	56.833,33	7.986.175,00	2.708.139,79

Source: Authors' calculation

Table 2. Total area under vegetable crops (ha)

	N	Minimum	Maximum	Mean
Cucumber G	30	0,05	1,50	0,41
Cabbage O	17	0,50	3,00	1,30
Pepper O	73	0,08	2,00	0,82
Pepper G	37	0,02	2,20	0,58
Tomato O	16	0,10	1,00	0,41
Tomato G	105	0,02	2,00	0,26

Source: Authors' calculation

When it comes to the representation of different production systems, cucumbers and tomatoes are predominately grown in greenhouses, whereas cabbage and peppers are grown in open fields.

For all vegetable crops in question, the farms predominately procured the seedlings from their own production (Table 3). Tomato seedlings are mostly procured from the market (43%). Pepper seedlings are least procured from the market (8.20%).

Table 3. Distribution by the method of seedlings procurement (%)

	Frequency	Percentage [%]
	Cucumber	
Purchase	4	13.30
Not applicable	0	0
Own production	26	86.70
	Cabbage	
Purchase	3	17.60
Not applicable	0	0
Own production	14	82.40
	Pepper	
Purchase	9	8.20
Not applicable	1	0.90
Own production	100	90.90
	Tomato	
Purchase	52	43
Not applicable	0	0
Own production	69	57

Source: Authors' calculation

When it comes to the method of production, seedlings are mostly produced in containers, namely cucumber, cabbage and tomato seedlings, by over 50% of farmers. Pepper seedlings are still predominately propagated in hot beds. Here it is clearly indicated there is a wide window for improvement and a more rationalised process of seedling production, particularly when it comes to pepper seedlings (Table 4).

Table 4. Method of seedlings production

	Frequency	Percentage [%]
	Cucumber	
Containers	23	76.70
Not applicable	4	13.30
Hot beds	3	10.00
Peat pellets	0	0
	Cabbage	
Containers	9	52.90
Not applicable	6	35.30
Hot beds	2	11.80
Peat pellets	0	0

	Frequency	Percentage [%]
	Pepper	
Containers	40	36.40
Not applicable	8	7.30
Hot beds	62	56.40
Peat pellets	0	0
	Tomato	
Containers	61	50.40
Not applicable	44	36.40
Hot beds	13	10.70
Peat pellets	3	2.50

Source: Authors' calculation

The highest cost of seed per hectare was recorded for tomato, amounting to RSD 752,220.48, followed by cucumber (RSD 253,374.55), pepper (RSD 493,620.84) and cabbage (RSD 81,185.29) (Table 5).

Table 5. Cost of seed given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	14.000,00	2.000.000,00	253.374,55
Cabbage O	17	1.500,00	300.000,00	81.185,29
Pepper O	73	7.000,00	1.600.000,00	242.290,26
Pepper G	37	75.000,00	1.100.000,00	493.620,84
Tomato O	16	4.000,00	1.500.000,00	470.927,08
Tomato G	105	57.346,00	2.400.000,00	752.220,48

Source: Authors' calculation

The highest cost for fertilizer per hectare was recorded in tomato production, amounting to RSD 229,524.87. The second highest was recorded in greenhouse pepper production (RSD 214,540.95) and open-field pepper production (RSD 114,578.60), while the lowest cost was recorded in cabbage production (RSD 59,721.76) (Table 6).

Table 6. Cost of fertilizer given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	11.400,00	513.680,00	83.988,90
Cabbage O	17	16.840,00	246.250,00	59.721,76
Pepper O	73	17.900,00	486.400,00	114.578,60
Pepper G	37	16.536,00	565.100,00	214.540,95
Tomato O	16	28.600,00	219.750,00	80.194,58
Tomato G	105	11.100,00	904.000,00	229.524,87

Source: Authors' calculation

The highest costs of crop protection per hectare was recorded in greenhouse tomato production (RSD 202,354.48). The second highest was recorded in greenhouse pepper production (RSD 159,425.63), followed by open-field pepper production, greenhouse cucumber production and cabbage production, respectively (Table 7).

Table 7. Cost of crop protection products given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	11.000,00	270.000,00	72.580,66
Cabbage O	17	3.000,00	170.000,00	51.952,94
Pepper O	73	7.296,00	620.000,00	96.282,95
Pepper G	37	6.000,00	750.000,00	159.425,63
Tomato O	16	19.400,00	255.000,00	65.918,75
Tomato G	105	15.000,00	500.000,00	202.354,48

Source: Authors' calculation

The cost of diesel-fuel was the lowest cost in vegetable production, percentage-wise. In greenhouse production such cost was almost equal for cucumber, pepper and tomato production, amounting to approximately 700 RSD/ha, being lower in open-filed production (Table 8).

Table 8. Cost of diesel fuel given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	0,00	1.900,00	783,15
Cabbage O	17	0,00	500,00	179,88
Pepper O	73	0,00	2.000,00	521,67
Pepper G	37	0,00	2.000,00	736,47
Tomato O	16	166,67	1.500,00	527,08
Tomato G	105	0,00	3.000,00	706,88

Source: Authors' calculation

Productivity-wise, labour was mostly required in greenhouse production, almost equally in cucumber, pepper and tomato production. In open-field production, labour cost was substantially lower (Table 9).

Table 9. Cost of labour given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	0,00	880.000,00	331.554,84
Cabbage O	17	8.000,00	141.666,67	70.188,77
Pepper O	73	0,00	750.000,00	172.887,22
Pepper G	37	0,00	840.000,00	310.221,54
Tomato O	16	0,00	500.000,00	82.962,50
Tomato G	105	0,00	1.100.000,00	296.572,32

Source: Authors' calculation

When it comes to the cost of machinery service (outsourced), the highest cost was in pepper production (Table 10).

Table 10. Cost of machinery service given by vegetable crops (RSD/ha)

	N	Minimum	Maximum	Mean value
Cucumber G	30	0,00	111.993.33	3.733,11
Cabbage O	17	0,00	0,00	0,00
Pepper O	73	0,00	250.000,00	12.592,24
Pepper G	37	0,00	146.533,33	7.185,23
Tomato O	16	0,00	0,00	0,00
Tomato G	105	0,00	119.320,00	1.136,38

Source: Authors' calculation

Table 11 shows the results of the correlation analysis for all four vegetable crops. When it comes to cucumber production, there is clearly a significant correlation between the total contribution margin and the total area under cucumbers. The coefficient of correlation implies there is a high negative correlation between the variable in question. A negative correlation coefficient implies that an increase in the total contribution value leads to a decrease in the total area under cucumbers and vice versa. Moreover, there is no significant correlation between the total contribution margin and other parameters in questions, which is confirmed by a low coefficient of correlation, indicating low interconnection.

Regarding pepper production, there is a significant correlation between the total contribution margin and the system of production. The values of correlation coefficient implies a moderate positive correlation between the observed variable. A positive correlation coefficient implies that an increase in the total contribution margin leads to more vegetables growing in greenhouses, whereas a decrease in the total contribution margin leads to more vegetable growing in open fields. Furthermore, it can be seen there is a significant correlation between the total contribution margin and representation of irrigation systems. A positive correlation coefficient implies that an increase in the total contribution margin leads to a higher percentage of representation of irrigation systems. Moreover, there is no significant correlation between the total contribution margin in pepper production and other parameters, which is confirmed by a low coefficient of correlation, indicating a low interconnection.

Table 11 shows a significant correlation between the total contribution margin in tomato production and the method of seedling procurement. A positive correlation coefficient indicates that an increase in the total contribution margin leads to predominately procuring seedlings from own production, whereas a decrease in the total contribution margin leads to purchasing seedlings from the market. Furthermore, there is a clear connection between the total contribution margin in tomato production and the percentage of representation of feeding systems. The values of correlation coefficient implies a moderate negative correlation between the variables in question. A negative coefficient of correlation indicates that an increase in the total contribution margin leads to a decrease in the percentage of representation of feeding systems and vice versa. Moreover, there is a significant correlation between the total contribution margin and the cost of diesel fuel. The values of correlation coefficient implies a low positive correlation between the variable in question. A positive correlation coefficient implies an increase in the total contribution margin leads to an increase in the cost of fuel and vice versa. There is no significant correlation between the total contribution margin in tomato production and other parameters in question, which is confirmed by a low coefficient of correlation, indicating a low interconnection.

When it comes to cabbage production, there is no significant correlation between the total contribution margin and the parameters in question, which is confirmed by low correlation coefficient, indicating a low interconnection.

Table 11. Correlation between the total contribution margin and other parameters

Variables	Total contribution margin			
	Cucumber	**Cabbage**	**Pepper**	**Tomato**
Total area under crops	-0.522**	0.063	-0.020	0.161
System of production	-	-0.185	0.327**	-0.027
Method of seedlings procurement	0.012	-0.157	0.003	0.182*
Method of seedlings production	0.285	0.268	-0.124	0.117
% representation of irrigation systems	-	-0.140	0.196*	-0.144
% representation of feeding systems	-0.213	-0.009	0.148	-0.390**
Cost of seed	-0.346	-0.007	0.047	-0.130
Cost of fertilizer	-0.189	0.008	0.124	0.033
Cost of crop protection products	-0.218	-0.193	-0.003	-0.042
Cost of diesel fuel	-0.335	0.282	-0.176	0.230*
Cost of labour	-0.275	0.026	0.036	-0.096
Cost of machinery service	-	-	0.078	0.187

(*Statistical significance at 0.05 ** Statistical significance at 0.01).

Conclusion

The prevailing vegetable crop in the representative sample is the cabbage, whereas tomatoes are grown on the lowest mean values of the total areas under crops. Cucumbers and tomatoes are mostly grown in greenhouses, whereas cabbage and peppers are mostly grown in open fields. One of the key factors of production is the use of quality and certified seeding material (seedlings). Currently, it is predominantly procured from own production with a tendency of specialisation and shifting to purchasing quality material. Farmers who grow tomatoes are most likely to purchase the seeding material (43%), while on the other hand, pepper growers still opt for their own production of seeding material, in hot beds predominantly, while only 8.20% of pepper growers purchase seedlings. Farmers who produce their own seedlings are most likely to use containers. The highest cost of seed were recorded in tomato production, amounting to 752,220.48 RSD/ha, in cucumber production 253,374.55 RSD/ha, pepper 493,620.84 RSD/ha and cabbage production 81,185.29 RSD/ha. The highest cost of fertilizer per hectare was recorded in tomato production, amounting to 229,524.87 RSD/ha. The second highest cost was recorded in greenhouse pepper production 214,540.95 RSD/ha, open-field pepper production 114,578.60 RSD/ha and cabbage production 59,721.76 RSD/ha. As for the cost of crop protection products per hectare, the highest cost was recorded in greenhouse tomato production, amounting to RSD 202,354.48, followed by greenhouse pepper production (RSD 159,425.63), open-field pepper production, greenhouse cucumber production, open-field tomato production and cabbage production, respectively. The cost of diesel-fuel was not significant, compared to other costs. When it comes to labour cost, labour was mostly required in greenhouse production, almost equally in cucumber, pepper and tomato production, and considerably lower in open-field production.

The correlation analysis of cucumber production has shown there is a significant correlation between the total contribution margin and the total area under cucumbers. The greenhouse production of peppers significantly defines the gross margin. Moreover, the irrigation system defines the gross margin to a significant extent. There is a significant correlation between the total contribution margin in tomato production and the method of seedlings procurement. A positive correlation coefficient indicates that an increase in the total contribution margin leads to procuring the seeding material from own production, whereas a decrease in the total contribution margin leads to predominately purchasing the seeding material.

A lack of labour and a need for more professional and more specialised production implies the necessity of purchasing quality seeding material as one of the key factors of competitive production.

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Investment Attractiveness of Shares of Agricultural Companies in the Republic of Serbia[89]

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Abstract

The purpose of the paper is to investigate the success of agricultural companies whose shares are listed on the Belgrade Stock Exchange and the investment attractiveness thereof. For the work, a portfolio of companies from the above industry whose shares are actively and permanently traded was selected. The paper first investigated and evaluated the business performance of the observed companies using ratio analysis, and then the movement of stock market indicators over the past ten years. This provided important information not only for the management of the analyzed companies but also for the makers of agricultural policy in the Republic of Serbia and the investment community.

Key words: investments, securities, agribusiness.

Introduction

Numerous events, such as the Covid-19 pandemic, and the war events in Ukraine, had significant implications for all economic activities. In addition

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to the numerous limitations that are inherent in agricultural production, the above-mentioned events have additionally affected not only the success of business operations in the field of agriculture but also food security.

The work aims at investigating the success of agricultural companies whose shares are listed on the Belgrade Stock Exchange as well as the investment attractiveness of their shares. A portfolio of farming companies whose shares are actively and permanently traded was selected.

The paper first investigated and evaluated the business performance of the observed companies using ratio analysis, then the attractiveness of shares and the movement of stock market indicators in the past ten years. This provided important information not only for the management of the analyzed companies but also for the makers of agricultural policy in the Republic of Serbia and the investment community.

Research results and discussions

The quantitative part of the analysis essentially consists of two parts. In the first step, collection and processing of data from the financial reports of agricultural enterprises (activity 0111 - Cultivation of grain (except rice), legumes, and oilseeds) in the period from 2013 to 2022 was carried out to see the basic characteristics and tendencies in the business of the analyzed subjects. By reviewing the data on share trading, it was established that only five companies recorded a trade volume sufficient to form a representative market price of shares.[93] The total research sample, therefore, consists of 48 observation units.[94] To calculate the selected financial indicators, data from the balance sheet, income statement, and cash flow report were used, which are publicly available through the singular database of the Agency for Business Registers. Since the considered companies are also listed on the

[93] Other authors who researched the operations of entities from the agricultural and food sector point out and refer to the limitation of the insufficient volume of turnover on the Belgrade Stock Exchange in the context of the analysis of the creditworthiness of listed companies. See Vučurević, S. (2015): *Functionality of creditworthiness in determining the market price of shares of companies in the agricultural and food sector in Serbia (doctoral dissertation),* University of Novi Sad, *Novi Sad*, pp. 186-189.

[94] Financial reports for 2022 were not available for two out of five companies. Therefore, all calculations for the year 2022 are based on data from three companies, and the total research sample consists of 48 units instead of 50.

stock exchange, the basic stock market indicators for the same period were subsequently considered.

The indicators based on which the assessment of the financial condition of agricultural enterprises was carried out include indicators of liquidity, indebtedness, business success, and business activities. The selected stock market indicators are market capitalization, earnings per share, the ratio of market price to net profit per share, and the ratio of market price to book value per share. The method of calculating the indicators and the corresponding reference values are given below (table 1).

Table 1. Overview of selected indicators

Indicator	Calculation	Reference value
Current liquidity ratio	Current assets/Short-term liabilities	2
Quick liquidity ratio	(Current assets-Inventories)/Short-term liabilities	1
Cash liquidity ratio	Liquid assets/Short-term liabilities	1
Liquidity ratio based on cash flows from business activities	Net cash flow from business activities/Short-term liabilities	0.4
Share of debt in liabilities	Debts/Total liabilities	min
ROA	Business profit/Average business assets*100	max
ROE	Net profit/Average equity*100	max
Turnover ratio of total business assets	Net sales revenue/Average total business assets employed	max
Turnover ratio of current assets	Net sales revenue/ Average employed working capital	max
Market Capitalization	The market price of shares * Number of shares in circulation	max
Net earnings per share (EPS)	Net earnings per share/Weighted average number of common shares in circulation	max
The ratio of market price to net earnings per share (P/E)	Market share price/Net earnings per share	1
The ratio of market price to book value per share (P/B)	Market price per share/Book value per share	1

Source: Author's systematization based on data from The Agency for Business Registers.

In the following, an analysis of the property structure of the given companies was first performed in the period from 2013 to 2022 (table 2).

Table 2. Balance sheet structure and the value of indicators financial security indicators in the period from 2013 to 2022

Balance position	Structure (%)									
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Fixed assets	62.2	64.4	66.0	65.2	67.7	67.1	68.7	79.7	82.7	83.4
Deferred tax assets	0.4	0.4	0.0	0.1	0.2	0.3	0.2	0.2	0.2	0.0
Current assets	37.4	35.1	34.0	34.8	32.2	32.6	31.1	20.1	17.1	16.6
Total assets	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Off-balance sheet assets	12.0	2.4	12.4	12.3	2.2	2.3	2.3	2.6	2.9	3.3
Capital	75.5	78.2	77.0	74.1	73.7	73.6	73.5	72.9	74.9	78.3
Long-term provisions and liabilities	6.6	7.2	8.1	6.8	8.1	6.6	4.5	5.4	4.9	4.6
Deferred tax liabilities	0.1	0.1	0.3	0.2	0.3	0.4	0.4	0.4	0.4	0.4
Short-term liabilities	17.8	14.4	14.7	18.8	18.0	19.4	21.7	21.4	19.9	16.7
Total liabilities	100.0	100.0	100.0	100.0	97.7	100.0	100.0	100.0	100.0	100.0
Off-balance sheet liabilities	12.0	2.4	12.4	12.3	2.2	2.3	2.3	2.6	2.9	3.3
Indicator	**Financial security**									
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Current liquidity ratio	2.85	2.82	3.51	3.37	3.63	5.30	4.89	3.55	3.90	1.57
Quick liquidity ratio	1.91	1.51	1.84	1.88	2.01	3.83	3.86	2.34	2.90	0.62
Cash liquidity ratio	0.07	0.02	0.05	0.28	0.18	0.81	0.19	1.09	1.27	0.49
Ratio liquidity based on cash flows from business activities	0.14	-0.06	0.06	0.19	-0.06	0.47	-0.54	0.15	0.22	-0.59
Share of debt in liabilities	31.85	28.67	29.36	32.78	33.15	31.72	31.21	31.36	30.35	26.90

Source: Authors' calculation based on data from The Agency for Business Registers.

The selected agricultural enterprises are characterized by a dominant share of fixed assets (from 62.2% to 83.4%), which is also a specificity of enterprises from other sectors of agriculture, primarily due to the existence of a large value of land that is not amortized. The previous property also applies in the case of perennial crops and basic herds, while real estate and equipment also constitute a significant part of fixed assets (Tomašević, 2020). There is also a tendency to increase the share of fixed assets in 2022. The former is a consequence of the increase in the value of certain items of fixed assets but also of a decrease in the value of current assets. Namely, all analyzed companies in the period from 2019 to 2022 recorded reductions in the most represented positions of current assets (inventories and receivables based on sales), primarily as a result of a similar decline in business income.

The structure of assets in terms of sources of financing is characterized by a relatively low representation of debts. Capital makes up 72.9% to 78.2% of total liabilities, while short-term liabilities make up a larger part of borrowed sources, from 14.4% to 21.7% of total liabilities. The relatively small share of long-term debt is primarily linked to unfavorable lending conditions in the agricultural sector, primarily in terms of mismatched repayment terms, interest rates and other lending conditions with specifics (small number of capital turnovers during the year) and recorded sectoral results, taking into account differences between individual lines of agricultural production.

The analysis of financial security indicators (liquidity and indebtedness) shows that agricultural enterprises conditionally record satisfactory liquidity, while the values of indebtedness indicators are almost always within the expected limits. Although average values higher than the reference ones were recorded (except in 2022) in the case of the first two liquidity indicators, about 50% of companies recorded a level lower than or around the predicted value. Some authors link low liquidity to the specifics of agricultural production, which concern unequal cash inflows during the business year, the pronounced seasonality of agricultural production and the influence of weather conditions, which, together with other factors, complicate the process of securing funds for payment of due obligations (Tomašević et al., 2019). It was noticed that the considered agricultural companies generally have negligible amounts of cash and cash equivalents, which is confirmed by the very low values of the cash liquidity ratio in most of the analyzed period. In the balance sheet from 2020 in the case of all five companies, at least a fourfold increase in the value of the most liquid assets was observed (the value of the indicator increased from 0.19 in 2019 to 1.09 in 2020 at a similar level of short-term liabilities) in response to changed business conditions due to the Covid-19 pandemic. A similar situation was recorded in 2021 while in 2022 the representation of these assets was significantly reduced, which remains about twice as high compared to the period until 2019. The former can also be observed by analyzing the liquidity indicator based on cash flow from business activities. Namely, in 2019 a lower and negative value than the reference once was recorded (-0.54), which was consequently recognized as the need to increase the representation of the most liquid asset position in the following year. Companies were also characterized by low indebtedness, primarily due to the already mentioned absence of long-term debt. Total debts in the analyzed period made up about 30% of total liabilities.

Table 3. Structure of the profit and loss account and the value of success and effectiveness indicators in the period from 2013 to 2022

Balance position	Structure (%)									
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Total income	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total expenditure	97.3	100.3	104.0	98.2	107.3	95.2	103.3	99.4	100.6	95.4
Business income	95.0	90.6	93.6	96.4	86.7	86.9	93.1	97.3	97.0	85.3
Business expenditure	92.9	94.2	95.1	92.1	98.9	90.3	98.9	94.8	93.4	91.5
Business result	2.2	(2.8)	(0.4)	4.3	(13.1)	(3.4)	(5.8)	2.6	3.5	(6.3)
Funding result	(1.4)	(2.3)	(3.6)	(1.2)	0.8	(0.6)	(0.1)	0.0	0.1	3.0
Other result	2.0	5.6	1.2	(1.3)	3.5	8.8	2.6	(2.0)	(4.2)	7.9
Net result	2.7	(0.3)	(6.9)	1.2	(9.1)	0.4	(9.5)	(0.4)	(1.9)	(6.1)
Indicator	**Business success and effectiveness**									
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
ROA	1.53	-1.86	-0.08	1.96	-3.68	-0.77	-1.36	-0.34	-0.43	-0.74
ROE	3.10	-1.22	-0.56	0.98	-4.06	1.52	-0.38	-0.86	-3.35	0.48
Turnover ratio of total business assets	0.58	0.24	0.21	0.29	0.18	0.26	0.20	0.17	0.16	0.14
Turnover ratio of current assets	1.52	0.69	0.67	0.96	0.56	0.96	0.77	0.74	0.88	0.79

Source: Authors' calculation based on data from The Agency for Business Registers.

The preliminary analysis of the profit and loss account indicates the changing performance of the considered companies, which is largely a consequence of realized losses at the level of business results. The aforementioned is especially worrying if it's taken into account that in 21 cases (44% of the sample), companies recorded a negative financial result. Low profitability is also confirmed by the calculated rates of return on assets and equity. The largest number of companies that achieved positive results recorded rates of up to 2% (17 cases or about 35% of the sample). The highest values of performance indicators were recorded in 2013 (rate of return on equity of 3.10%) and 2016 (rate of return on assets of 1.96%). The previously established general decrease in income from 2019 was directly reflected in the decrease in business success, while the lowest rates from 2017 were also a consequence of a significant increase in business expenses.

The authors point out the need to compare the effects of business activities with the state of liquidity, i.e. the mutual conditioning of the two business dimensions (Krasulja & Ivanišević, 2005). The turnover ratio of total business assets has been extremely low since 2014 (0.14 to 0.24 turnover per year), following the established dominant share of high-value fixed assets, which are also less profitable compared to current assets.

Table 4. Values of stock market indicators of companies in the period from 2013 to 2022

Indicator	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Market capital.[95]	2,132	2,127	2,082	1,950	1,955	1,942	1,924	1,932	2,558	2,665
EPS	51.94	66.77	97.83	42.38	15.45	146.96	85.93	19.15	41.13	67.88
P/E	46.74	171.89	26.47	42.63	386.83	880.97	737.13	84.80	64.31	82.93
P/B	2.02	2.06	1.96	2.07	2.10	1.88	1.75	1.70	2.06	1.33

Source: Author's calculation based on data from the Belgrade Stock Exchange: https://www.belex.rs/ (date of access: 11.04.2023).

By comparing the market capitalization with the book value for the given period, it is observed that the market value is lower for three of the five analyzed companies. When it comes to earnings per share, significant oscillations were observed as well as extremely low values in 2017 and 2020. Although the values of the earnings per share and market capitalization indicators should be conditional, this was not the case for the

[95] In millions of dinars.

entire analyzed period. Specifically, in the first three analyzed years, there was an increase in earnings per share that wasn't accompanied by an increase in market capitalization. The values of P/E ratios also show extreme change, which is a direct result of the volatile values of the earnings per share indicators. The high value of the given ratio is also a consequence of the low value of profit per share, which was clearly noticed in 2017. The ratio of the market price to the book value of shares for the analyzed period is higher than one, which indicates the success of the given companies. However, the growth of investors' confidence in the future results of the given companies cannot be stated since the value of shares was volatile during the analyzed period.

Conclusion

The investment attractiveness of the company is a kind of reflection of its property, financial, and yield positions. As such, investment attractiveness is an important indicator of the risk of investing in securities issued by the company (debt instruments and equity instruments). For the assessment, a detailed ratio analysis of key business indicators was first implemented, followed by an analysis of stock market indicators for companies in the field of agricultural production whose shares are traded on the Belgrade Stock Exchange during a ten-year period. The obtained results indicate that the relatively low profitability and liquidity problems faced by the companies in the previous period resulted in the market value of three of the five analyzed companies being lower compared to their book value. All this suggests that the attractiveness of shares of agricultural production companies for participants on the Belgrade Stock Exchange is relatively low. The reasons, among other things, should be found in the low market price of cereals on the Product Exchange, which at certain times was significantly lower than the producer's cost price.

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Experiences of European Countries in Cooperative Credit Institutions[96]

Marija NIKOLIĆ[97], Vladimir ZAKIĆ[98]

Abstracts

One of the oldest forms of cooperatives in the world and an indispensable segment of the developed cooperative sector are savings and credit cooperatives. Originally established to provide small artisans and farmers with adequate sources of financing, savings and credit cooperatives have evolved into many different forms and organizations, from small savings and credit cooperatives operating at the local level to international financial giants. This paper analyzes the experience of European countries in the creation and business of savings and credit cooperatives in order to examine the achievements of this sector and the different ways in which these organizations function. The research has shown that the stages of development, the level of commitment to the cooperative sector and the external sources of funding are some of the key factors that determine the strength and position of savings and credit cooperatives in the financial market in Europe.

Key words: saving and credit cooperatives, experiences, Europe, banking

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Introduction

After first consumer cooperatives, savings and credit cooperatives emerged in Germany and rapidly spread throughout Europe and the world. Today, in Western European countries where the cooperative sector has developed unhindered, savings and credit cooperatives have an increasingly important position in the financial market, occupy significant market share, and grow beyond the traditional framework of cooperative organizations. This is how the first cooperative banks were born.

Cooperative financial organizations are savings and credit cooperatives (SCCs) and cooperative banks. In principle, both organizations operate in accordance with cooperative principles and offer their members favourable financial services. The differences between savings and credit cooperatives[99] and cooperative banks are reflected in the size of their assets, membership, and the scope and type of financial services they offer. Saving and credit cooperatives are smaller organizations whose members are mostly individuals and provide basic financial services, while cooperative banks have more significant assets, their members are mostly legal entities, including SCCs, and provide a wide range of financial services.

Savings and credit cooperatives in European countries have undergone a varied development. In Western European countries, they developed smoothly, often with government assistance and protection. In Eastern European countries, cooperatives were neglected, used to achieve political goals, and in some cases their normal functioning was prevented. The aim of this paper is to analyze the extent to which disruptions in the existence of the cooperative sector have affected the structure and level of development of financial cooperative institutions in European countries.

Results and Discussion

Financial cooperative sector in developed European countries

The first cooperatives were founded in Western Europe, where the socio-economic conditions that led to the creation of these organizations emerged as capitalism developed. Since those early days, cooperatives have developed continuously in these countries, with greater or lesser intensity, but without periods of complete stagnation or even abolition, as is characteristic of coun-

[99] Shorter ‘credit cooperatives’ or ‘cooperative unions’ as they are commonly called in English

tries of Central and Eastern Europe. This smooth development has favoured the emergence of a strong, complex and successful cooperative sector, in which savings and credit cooperatives have a special role and importance.

The beginnings of credit cooperatives date back to **Germany** in the mid-19th century and are associated with the activities of two extraordinary individuals: Friedrich Willhelm Raiffeisen and Franz Hermann Schulze-Delitzsch. By the end of the 19th century, savings and credit cooperatives in Germany had established a business network with thousands of organizations, and their positive experiences led to the adoption of these ideas in other European countries. Traditionally, there are two types of cooperative banks: the Raiffeisen Banks, associated with rural areas, and Folks banks (*Volksbanken*), associated with the ideas of Schulze-Delitzsch and urban areas. Today, they form a unique cooperative banking network in Germany.

The German banking system is based on three pillars: commercial banks, savings banks and cooperative banks. Cooperative banks mainly serve small and medium-sized enterprises and individuals in rural areas and smaller towns, while their presence is weaker in large urban centres. The success of the cooperative banks in Germany is based on a financial network consisting of two levels: the local cooperative banks, which operate according to cooperative principles, and the central financial institutions, which act primarily as commercial banks. The local cooperative banks enjoy a high degree of independence. They provide basic banking transactions, while other banking services are often provided in cooperation with or 'passed on' to central financial institution. This collaboration is not compulsory in nature, but it is assumed that local banks use various services provided by the DZ Bank (especially considering that they are not only customers, but also co-owners/shareholders) when conditions are more favourable or equivalent to those in the market (Anguren & Marqués, 2011).

The German credit cooperative movement is one of the most developed in Europe. According to the National Association of German Cooperative Banks, there are 772 cooperative banks operating in this country with 8,074 branches. They have over 30 million customers, 18.2 million of whom are also members and co-owners of these banks.[100] The most important central financial institution is DZ-Bank (*Deutsche Zentral-Genossenschaftsbank*), which is the pillar of the German cooperative banking.

[100] www.bvr.de

The roots of cooperative banking in **France** lie in the last decades of the 19th century. From the beginning of the development of cooperative banking, there was a pronounced influence of the state, which treated cooperative banks as 'organisations with special status' that received direct financial support from the state (Richez-Battesti & Leseul, 2016). In terms of volume of business activities and size of capital, cooperative banking in France is among the leaders in Europe. It consists of three groups: (1) Crédit Agricole, (2) BPCE Group and (3) Crédit Mutuel. These three cooperative groups are among the five largest French banking groups in terms of asset size. Their 330,000 employees (2/3 of total employees in the banking sector) and 25,000 branches serve 26 million members. They have a dominant 60% share of the 'retail' banking and, with 73% of bank branches in France, lend to 75% of small and medium-sized enterprises. More than 90% of the French population has an account with one of the cooperative banks (Pflimlin, 2019).

The first cooperative banks in the **Netherlands** were established in 1896, and two central cooperative financial institutions were founded just two years later. After World War II, a significant development of local cooperative banks began, turning to 'retail' banking and increasingly providing services to non-members. In the mid-1950s, more than 1,500 local cooperative banks were operating. As they grew stronger, there was a need to unite in order to operate more efficiently and strengthen market position. Thus, in 1972, a single central institution *Coöperatieve Centrale Raiffeisen-Boerenleenbank* or Rabobank was founded. This merger led to the formation of a powerful cooperative bank, both locally and internationally. After the merger, the number of local cooperative banks has decreased to only 84 in 2021. These cooperative banks are extremely strong organizations with 2.1 million members and almost 9 million customers and a market share of 21% of mortgage loans and 35% of savings deposits (Rabobank, 2021). For this reason, Rabobank is today one of the leading banks in the world, with the goal of becoming a globally recognized bank in the field of agriculture.

The development of modern cooperative banking in **Italy** differs from that in the European countries mentioned above, which is why this cooperative system is relatively weak. The first cooperative banks emerged in the 1880s and were supported by the Catholic Church and the pope. The influence of the fascist authorities on their business in the 1920s led to the withdrawal of deposits and a decline in their number. After World War II, the cooperative banking sector was restored and today consists of two main types of financial organizations: larger public banks and smaller cooperative credit banks (*Banche di credito cooperative – BCC*). Public banks today appear in two forms. Legislative changes in 2015 transformed public banks with assets of more than 8 billion euros into traditional joint stock companies, which significantly reduced the size of the cooperative financial sector. The remaining smaller public banks have retained some characteristics of cooperatives, but are actually a hybrid form of cooperative and commercial banks. Credit cooperative banks (BCCs) continued to operate at the local level and were able to maintain their cooperative identity, which manifests itself in providing more favourable loans to members compared to non-members (Catturani & Lucia, 2016).

Countries in which the development of savings and credit cooperatives was interrupted by a change in external conditions

In some countries, the development of savings and credit cooperatives took place in several separate phases. Due to changing external conditions caused by political, economic or other factors, SCCs in these countries were dissolved after the first phase of relatively successful development and re-established after some time. This is characteristic of the so-called Eastern Bloc countries.

Credit cooperatives emerged in **Ukraine** in the second half of the 19th century, following the Raiffeisen model. After a period of successful development and an increase in their number, the entire cooperative movement in Ukraine was abolished by the Soviet occupation.[101] After gaining independence, the financial market in Ukraine was renewed. A large number of commercial banks are formed, and the re-establishment of credit cooperatives also begins. The emergence of the system of credit cooperatives took place in a time of considerable turbulence, such as the hyperinflation of the 1990s, the so-called Orange Revolution (2004) and the international economic crisis of 2008.[102] In the absence of a law until 2001, various organisations involved in the so-called pyramid savings used the name '*credit cooperative'* which damaged the credibility of these organisations.[103]

Despite these difficulties, SCCs were emerging in Ukraine with considerable help from an extremely strong and organized diaspora, other

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[101] https://risu.ua/en/credit-unions-in-ukraine_n49656

[102] https://www.caidp-rpcdi.ca/best-practices-case-canadian-assistance-ukrainian-credit-unions

[103] https://risu.ua/en/credit-unions-in-ukraine_n49656

countries and international organizations.[104] The Polish cooperative movement provides technical and staff training assistance, and then starts the Canadian program of supporting the establishment of credit cooperatives, which is the result of a strong diaspora in this country (Malinowska, 2015). In addition, USAID, with the support of the World Council of Credit Unions (WOCCU), is launching a project to strengthen credit cooperatives and the quality of financial services they offer to participants in agribusiness in rural areas.

Although they have proven to be more resilient to changes in external business conditions compared to banks, the number of credit cooperatives, their members and clients, as well as the volume of savings have declined in the period from 2008 to the present. Recent events on the territory of Ukraine have further threatened the work of credit cooperatives.

Credit cooperatives in **Lithuania** developed in a similar way. Before the beginning of the II World War, there were over 300 credit cooperatives in this country with 119.000 members. At the end of the war, Lithuania became part of the Union of Soviet Socialist Republics (USSR), which ended their existence. A few years after gaining independence, in the mid-1990s, the idea of reviving cooperative financial organizations emerged in Lithuania. Significant financial, technical and advisory support to credit cooperatives in this country was provided by international financial institutions (USAID - United States Agency for International Development and CIDA - Canadian International Development Agency) and individual countries (USA and Canada).

Credit cooperatives in Lithuania include savings and credit cooperatives and central credit cooperatives, whose task is to maintain the liquidity and solvency of the sector, exercise supervision and control, and provide various financial and other services. Since the adoption of the first law on credit cooperatives in 1995, legislation has changed significantly several times, which had also affected the way these organizations operate. The amendments to the Act from 2000 created the conditions for improving the system of credit cooperatives. The state paid substantial funds and thus became a co-owner of the central credit cooperative, but it is also envisaged that the credit cooperatives will fully take over the state share over time (Liutvinskiene & Meskauskaite-Cilliers, 2016). In 2021, there were two central credit cooperatives operating in Lithuania with a total of 56 members (individual credit cooperatives), accounting for 2.6% of total banking sector

[104] http://www.wcuc.org.ua/about.0.html

assets. The majority of credit cooperatives performed positively in the same year, while only three recorded losses (Lietuvos bankas, 2023).

Although the first cooperative organizations in **Greece** were formed at the beginning of the 20th century, the development of this sector is late compared to Western Europe. First credit cooperatives started in 1990's, as a result of harmonization with European regulations. Cooperative financial organisations emerge as credit cooperatives, which provide limited financial support to their members, and as cooperative banks, which provide almost all types of banking services. The main obstacle to the creation of credit banks is providing the minimal initial capital. In Greece, a unique solution has been adopted, according to which the amount of founding capital of cooperative banks depends on the size of the area in which the bank will operate (the minimum capital is 6 million euros for the selection of only one of the 52 smaller areas and up to 18 million euros for the whole of Greece). In addition, the Greek government used European Union funds to approve incentives for the conversion of credit unions into cooperative banks. Starting from the experience of the most developed EU countries, cooperative banks and credit unions established the central Panellinia Bank as a joint stock company in 2001. One of the main shareholders was the German central cooperative banking institution DZ Bank, which provided major financial and organizational support.

As a result of the global economic crisis, which particularly affected Greece, the development of the cooperative banking system stagnated. In 2020, only six cooperative banks were still operating. Although their total assets are modest, their activity is important at the local level, as they have a market share of about 20% and provide 85% of loans to small and medium-sized enterprises (Mylonakis, 2020).

Credit cooperatives in the countries formed on the territory of the former SFRY

In the countries that emerged on the territory of the former SFRY, the development of the cooperative sector, including savings and credit cooperatives, was similar. The first cooperatives of this type appeared in the second half of the 19th century, mostly on the model of Raiffeisen credit cooperatives. After the first wave of accelerated growth in the number of credit cooperatives and the expansion of their activities, the upward trend continued until the World War II. In the post-war period, credit cooperatives share the fate of other types of cooperatives and go through various deviation processes. In this period, the financing of agriculture and the cooperative sector was taken over by savings and credit services, organized mainly in agricultural cooperatives, which were the most developed in that period. This phase of development lasted until the dissolution of the SFRY. After that, savings and credit cooperatives have gone through different stages of development in newly formed countries.

After independence, three types of savings and credit cooperatives emerged in **Croatia**, of which only craft and agricultural cooperatives were true cooperatives. The other two forms were not true cooperatives and served to legally invest capital at unrealistically high interest rates or to finance the operations of individuals and their enterprises. Such organizations represent distortions of the cooperative forms, which, together with the instability of the banking system at the time, seriously threatened the entire system of savings and credit cooperatives (Ministry of Finance, 2002). With the adoption of the Law on Savings and Credit Cooperatives in 2002, this area was partially regulated, although certain fraud cases were still recorded. To prevent the loss of confidence not only in these, but in all financial institutions, the Law on Credit Unions was adopted in 2006, with the assumption that the change of name would help restore confidence in SCCs. The new law did not bring the expected changes, and the number of SCCs rapidly declined to only 20 credit unions (Babić & Račić, 2011).

Credit cooperatives in **Slovenia** have developed in a similar way. In 1990, agricultural and forestry cooperatives and the Union of Savings and Credit Cooperatives established the Agricultural Cooperative Bank as a limited liability company. Two years later, after Slovenia's independence, the Cooperative Act was adopted, but since there were few cooperatives at that time, they did not receive much attention in this document (Avsec and Modić, 2009). After Slovenia joined the European Union in 2004, banking regulations were significantly tightened. The Agricultural Cooperative Bank took over all savings and credit services and changed its name to Deželna bank of Slovenia doo in 2004. Its largest shareholder is Kapitalska zadruga, legal successor to the Union of Savings and Credit Cooperatives (Avsec, 2016).

After independence, the establishment of SCCs in **Macedonia** started almost from scratch, but with significant financial support from the World Council of Credit Unions (WOCCU) and USAID. The first and still the only credit cooperative FULM (*Финансиски Услуги за Лугето на Македонија*) was established in 1999 and today has more than 12,000 members. In its activity, this cooperative encountered numerous difficulties, which it overcame relatively well with the help of foreign organizations, but it cannot be said that credit cooperatives in this country have achieved significant success.

Serbia is proud of its long cooperative tradition, which began with the first agricultural credit cooperatives. More than other types of cooperatives, SCCs had a difficult path of development, which ended at the beginning of the 21st century with a change in legal regulations that completely abolished this form of cooperatives. The previously presented experiences of European countries should indicate the need to re-establish SCCs in Serbia, as well as possible solutions that can be applied in this process.

Conclusion

Cooperative financial institutions exist in almost all economies of European countries, regardless of the level of development, size, development of the cooperative sector and other indicators. The paper presents the experience of selected European countries with the development of SCCs, in order to examine whether the current state of cooperatives depends on whether these organizations have developed continuously, without periods of stagnation.

Savings and credit cooperatives in Western European countries have been able to operate and develop unhindered since their inception. In some countries they were supported financially, legally and institutionally to a greater or lesser extent by the state, but there was no historical period in which the work of these and other types of cooperatives was obstructed in any way. In contrast to these countries, in the Eastern and Central European countries after the World War II, as well as in later stages, the activities of SCCs were banned, their property confiscated, and their members alienated. It can be concluded from the research that in the first group of countries where cooperatives functioned smoothly, cooperative financial institutions are an important segment of financial markets and operate in many different forms. In contrast, in the countries where SCCs were established too late for various reasons or where there were periods when they could not function, cooperatives have a weaker market position and it is difficult to compete with commercial banks.

Savings and credit cooperatives play an important role in the financial market. Although they are often modest in terms of capital and the types of services they provide, they often represent the only source of low-cost credit for a segment of the population that does not have access to the services of commercial banks. Savings and credit cooperatives are important in this sense not only because they are an important segment of the cooperative sector, but also because their existence has social implications.

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Agricultural Insurance in Serbia, Croatia and in the Republic of Srpska

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Abstract

The aim of the paper is to present the structure of agricultural insurance policies in the Republic of Serbia, in the Republic of Croatia, as well as in the Republic Srpska. In the current conditions of severe climate change, agricultural insurance can be considered a necessary agrotechnical measure in plant production, and due to increasing risks, it is also necessary in livestock production. The authors analyze the total number of agricultural insurance policies in the period from 2014 to 2021 and conclude that crop and fruit insurance policies dominate their structure in the Republic of Serbia, as well as in the Republic of Croatia. In the structure of agricultural insurance policies in the Republic Srpska, livestock insurance policies have a dominant role.

Key words: agricultural insurance, agricultural insurance policies, crop and fruit insurance policies, livestock insurance policies

Introduction and literature review

Agricultural insurance is a type of property insurance that combines crop production insurance, livestock insurance and several special subtypes of insurance that cover risks that threaten agricultural production or only certain insurance items (Radović, 2016). Some authors (Žarković, 2016) point out that in recent years the achievements of biotechnology and genetic technology are increasingly important in agriculture, and the risks are

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increasing, and thus the need for insurance is becoming more pronounced. In general, all researchers in this field agree that agricultural insurance "plays a significant role within measures to protect and improve agricultural production" (Sredojević et al., 2010, p. 207).

The importance of agricultural insurance is often considered in the literature from the aspect of risk management. In this sense (Roberts, 2005, p. 93) defines agricultural insurance as "a segment of risk management, and its development depends on the cost-benefit ratio at the level of agricultural holdings or agricultural enterprises, as well as on the potential offer on the insurance market". According to (Mishra, 1995, p. 286) "agricultural insurance, particularly crop insurance, exists in many countries as an institutional response to the current risks accompanying agricultural production". Also, (Chambers & Quiggin, 2004, p. 203) state that "there are several types of risk management available in agriculture, and one of them will almost inevitably be the purchase of an insurance policy in any risk management program".

Crop insurance has been around for almost three centuries. In Europe, crop production insurance against hail risk first appeared in 1719 in Germany (Swiss Re, 2011, p. 1). Today, on a global level, crop production insurance accounts for about 90% of the total agricultural insurance premium (Iturrioz, 2009, p. 11). In modern conditions, crop insurance based on weather indices is increasingly being applied (Hohl, 2019).

There is a widespread opinion in the literature that insurance of crop production is one of the riskiest insurances and therefore insurance protection is provided only for a limited number of risks (Petrevska et al., 2010). The basic insurable risks of crop production include: hail, fire and lightning. The risk of hail is the most prevalent both in terms of frequency and severity of consequences. It is estimated that in the Republic of Serbia, 90% of plant production insurance is city risk insurance. Additional insurable risks of plant production are storm, flood, spring and autumn frost (Priručnik, 2015, p. 397).

In Serbia, there is a need for the development of the agricultural insurance market. Despite the high subsidies of agricultural insurance premiums, which range from 40% to 70%, agricultural insurance is insufficiently developed. The scope of insured agricultural plots is low, only up to 10% of the total agricultural area is insured. According to research (Vasiljević et al., 2014). the unfavorable structure of agricultural insurance is also observed, so that insurance against one type of risk, most often the city, dominates, while forms of yield or income insurance are not represented. Therefore, it can be stated that before the responsible creators of agricultural policy is a significant task of creating legal and other conditions for the establishment of modern instruments for risk management in agriculture (Vasiljević et al., 2020).

Until the accession of this country to the European Union in 2013, farmers in the Republic of Croatia had the right to subsidies for agricultural insurance premiums of up to 25% from the state budget and, most often, another 10% from the budget of local governments. The amount of subsidies has been increased since 2018. Subsidies are now paid up to 70% of the insurance premium. 85% of the funds from the budget of the European Union and 15% of the funds from the budget of the Republic of Croatia participate in the payment of these subsidies. According to data from the Ministry of Agriculture of the Republic of Croatia, 9,347 requests from farmers for subsidies were submitted in 2019, which is almost four times more than in 2016 (Ministry of Agriculture, Republic of Croatia). The above confirms that these changes had a favorable impact on the development of agricultural insurance (Radović, 2020).

In the Republic Srpska, up to 50% of the agricultural insurance premium is regressed, but this type of insurance is insufficiently developed. According to research (Radović et al., 2022), the average share of the total agricultural insurance premium in the total non-life insurance premium, in the period from 2014 to 2021, was only 0.6%.

Methodology and data sources

The aim of the paper is to present the structure of agricultural insurance policies in the Republic of Serbia, in the Republic of Croatia, as well as in the Republic Srpska. The paper uses the method of analysis and synthesis, the method of comparison and the method of descriptive statistics. The sources of data are the websites of competent institutions for monitoring agricultural insurance results, as well as the ministries of agriculture in the Republic of Serbia, in the Republic of Croatia, and in the Republic Srpska.

Research results

In order to analyze the structure of agricultural insurance policies in the Republic of Serbia, in the Republic of Croatia, as well as in the Republic Srpska, the total number of agricultural insurance policies is analyzed, that is, the number of crop and fruit insurance policies and the number of livestock insurance policies. The number of agricultural insurance policies is analyzed in the period from 2014 to 2021.

Table 1. Number of crop and fruit insurance policies 2014-2021

Year	Republic of Serbia Number of crop and fruit insurance policies	Republic of Croatia Number of crop and fruit insurance policies	Republic of Srpska Number of crop and fruit insurance policies
2014	19,768	14,625	53
2015	27,652	13,315	131
2016	28,749	20,596	335
2017	30,346	22,359	245
2018	39,212	39,299	330
2019	45,093	47,666	253
2020	42,603	46,963	288
2021	45,297	50,550	256
Total:	**278,720**	**255,373**	**1,891**

Sources: NBS, HANF-a, AORS. Edited by the authors.

The number of crop and fruit insurance policies in the Republic of Serbia had a growing trend until 2019. Although in 2019 there was a significant increase in the percentage of subsidies, in 2020 the number of crop and fruit insurance policies was reduced by 6% compared to the previous year. The growth trend continued in 2021, when the number of crop and fruit insurance policies increased by 6.3% compared to the previous year (table 1).

The number of crop and fruit insurance policies in the Republic of Croatia recorded significant fluctuations in the analyzed period. The growth trend was recorded from 2015 to 2019. In 2020, a decrease in the number of crop and fruit insurance policies was recorded by 1.5% compared to the previous year. It is noted that in this country, as well as in the Republic of Serbia, the number of crop and fruit insurance policies decreased in 2020, although the percentage of agricultural insurance premium subsidies increased in 2018. The growth trend continued in 2021, when the number of crop and fruit insurance policies increased by 1.1% compared to the previous year (table 1).

The number of crop and fruit insurance policies in the Republic Srpska also recorded significant fluctuations in the analyzed period. The growth trend was recorded only from 2014 to 2016, from 2017 to 2018 and from 2019 to 2020 (table 1).

Table 2. Share of the number of crop and fruit insurance policies in the total number of agricultural insurance policies 2014-2021

Year	**Republic of Serbia** **Share of the number of crop and fruit insurance policies in the total number of agricultural insurance policies (in %)**	**Republic of Croatia** **Share of the number of crop and fruit insurance policies in the total number of agricultural insurance policies (in %)**	**Republic of Srpska** **Share of the number of crop and fruit insurance policies in the total number of agricultural insurance policies (in %)**
2014	78	88	34
2015	83	89	58
2016	84	94	24
2017	89	94	17
2018	90	96	19
2019	91	93	76
2020	93	92	84
2021	93	91	88
Total:	**89**	**92**	**32**

Sources: NBS, HANF-a, AORS. Edited by the authors.

The average percentage share of the total number of crop and fruit insurance policies in the total number of agricultural insurance policies in the analyzed period was the highest in the Republic of Croatia (92%), followed by the Republic of Serbia (89%), and the lowest in the Republic Srpska (32%). When analyzing individual data, it can be stated that the percentage share of the total number of crop and fruit insurance policies in the Republic of Serbia recorded a growth trend in the entire analyzed period (table 2).

In the Republic of Croatia, the percentage share of the total number of crop and fruit insurance policies had a growing trend from 2014 to 2018, and in the following period it recorded a decline. In the Republic Srpska, the percentage share of the total number of crop and fruit insurance policies had significant oscillations, but also a pronounced growth trend from 2018, ending in 2021 (table 2).

The total number of livestock insurance policies in the Republic of Serbia recorded significant fluctuations in the analyzed period, but also a marked downward trend from 2019, ending in 2021. The above can be explained by the significant reduction of livestock in this country in recent years. The total number of livestock insurance policies decreased by 40% in 2021 compared to 2014 (table 3).

Table 3. Number of livestock insurance policies 2014-2021

Year	Republic of Serbia Number of livestock insurance policies	Republic of Croatia Number of livestock insurance policies	Republic of Srpska Number of livestock insurance policies
2014	5,466	1,998	103
2015	5,564	1,620	96
2016	5,313	1,385	1,056
2017	3,642	1,367	1,174
2018	4,506	1,813	1,445
2019	4,472	3,688	83
2020	3,376	4,104	53
2021	3,280	4,875	35
Total:	**35,619**	**20,850**	**4,045**

Sources: NBS, HANF-a, AORS. Edited by the authors.

The total number of livestock insurance policies in the Republic of Croatia also recorded significant fluctuations in the analyzed period. The growth trend has been recorded since 2017, ending in 2021. The total number of livestock insurance policies in this country increased by 44% in 2021 compared to 2014 (table 3).

In the Republic Srpska, the largest fluctuations in the total number of livestock insurance policies were recorded in the analyzed period. For example, their number increased in 2016, compared to 2014, by more than ten times. From 2016, until 2018, a growth trend was recorded, and from this year onwards, a marked decline. The total number of livestock insurance policies in the Republic Srpska decreased by 69% in 2021 compared to 2014, i.e. the initial year of the analyzed period (table 3).

Table 4. Share of the number of animal insurance policies in the total number of agricultural insurance policies 2014-2021

Year	Republic of Serbia Share of the number of livestock insurance policies in the total number of agricultural insurance policies (in %)	Republic of Croatia Share of the number of livestock insurance policies in the total number of agricultural insurance policies (in %)	Republic of Srpska Share of the number of livestock insurance policies in the total number of agricultural insurance policies (in %)
2014	22	12	66
2015	17	11	42
2016	16	6	76
2017	11	6	83
2018	10	4	81
2019	9	7	24
2020	7	8	16
2021	7	9	12
Total:	**11**	**8**	**68**

Sources: NBS, HANF-a, AORS. Edited by the authors.

The average percentage share of the total number of livestock insurance policies in the analyzed period was the highest in the Republic Srpska (68%), followed by the Republic of Serbia (11%), and the lowest in the Republic of Croatia (8%). When analyzing individual data, it can be stated that the percentage share of the total number of livestock insurance policies in the Republic of Serbia recorded a downward trend in the entire analyzed period (table 4).

In the Republic of Croatia, the percentage share of the total number of livestock insurance policies had a downward trend from 2014 to 2018, and in the following period it recorded an increase. In the Republic Srpska, the percentage share of the total number of livestock insurance policies had significant oscillations, but also a marked downward trend from 2018, ending in 2021 (table 4).

Table 5. Total number of agricultural insurance policies 2014-2021

Year	Republic of Serbia Total number of agricultural insurance policies	Republic of Croatia Total number of agricultural insurance policies	Republic of Srpska Total number of agricultural insurance policies
2014	25,234	16,623	156
2015	33,216	14,935	227
2016	34,062	21,981	1,391
2017	33,988	23,726	1,419
2018	43,718	41,112	1,775
2019	49,565	51,354	336
2020	45,979	51,067	341
2021	48,577	55,425	291
Total:	**314,339**	**276,223**	**5,936**

Sources: NBS, HANF-a, AORS. Edited by the authors.

The total number of agricultural insurance policies in the Republic of Serbia in the analyzed period was 314,339, in the Republic of Croatia 276,223, and in the Republic Srpska 5,936 (table 5).

Conclusion

Based on the conducted research, it can be concluded that the insurance of plant production is more common in the Republic of Serbia and the Republic of Croatia, while in the Republic Srpska the insurance of livestock production is more common. Specifically, in the structure of the total number of agricultural insurance policies in the analyzed period from 2014, and ending with 2021, in the Republic of Serbia, as well as in the Republic of Croatia, crop and fruit insurance policies had a dominant share. In the structure of the total number of agricultural insurance policies in the Republic Srpska, in the analyzed period, livestock insurance policies had a dominant share.

It can also be stated that agricultural insurance is not sufficiently developed considering the existence of agricultural insurance premium subsidies. The subsidies amount to: in the Republic of Serbia from 40% to 70%, in the Republic of Croatia up to 70%, and in the Republic Srpska up to 50%. However, even the mentioned subsidies do not sufficiently influence the increase in demand for agricultural insurance. The number of crop and fruit insurance policies in the Republic of Serbia and the Republic of Croatia is considerable, but it could be much higher, taking into account the total number of registered agricultural holdings in both countries. Also, the same interpretation applies to the number of livestock insurance policies in the Republic Srpska. Therefore, there is a need for continuous education of potential policyholders about the importance of agricultural insurance.

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What We Know About Women in Rural Areas? The Lack of Gender-Segregated Data

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Summary

Gender equality is one of the EU's core values and the EU institutions have recognised the problem of inequality, recent literature shows that there has been no or little progress. This is particularly pronounced for women in rural areas. In both Croatia and the European Union, rural women face various constraints, their work is often statistically unrecognised and referred to as "invisible labour" and it is often difficult for women to find or retain suitable, stable paid work. The lack of studies on the economic and social obstacles faced by women in rural areas can be explained by the lack of official gender-specific data. Croatia's main policy documents for the period 2023 - 2027 do not include measures that focus exclusively on women. Diverse and detailed statistical data aimed at capturing crucial lacks in the current type of data should provide the necessary background for any policy making.

Key words: rural areas, women, gender equality, data

Introduction

One of the core values of the European Union (EU), recognised already in the Treaty of Rome (1957), is equality between women and men (Eurostat, 2022). Since the late 1970s, EU institutions have recognised the problem of inequality in women's professional status. Series of directives that have been adopted made a significant contribution to the effective promotion of gender equality. Despite all the policies aimed at gender equality, recent literature shows the lack of progress and the problems faced

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by women, especially women from rural areas. In the EU, rural women face various constraints, including limited access to services, rural organisations, productive infrastructure, and technology. Women leave rural areas more often than men, are less involved in the labour market, have a higher risk of becoming unemployed, and are much more represented in the informal economy. They also perform disproportionately more unpaid work and household responsibilities. Their work is often statistically unrecognised and referred to as "invisible labour" and it is often difficult for women to find or keep suitable, stable paid work. This leads to a persistent trend of women being paid less than men globally. Although women are critical to the sustainability of rural households and local communities because their work contributes to the economic sustainability of households, farms, and local communities, their role and importance are often overlooked. At the EU-28 level, women entrepreneurs make up only one-third of self-employed workers, while women farmers manage only 30 percent of farms (Franić and Kovačićek, 2019).

A 2019 study prepared for the European Parliament (EP) on the occupational status of rural women in the EU shows that women make up 50 percent of the rural population and 45 percent of the economically active population, and that about 40 percent of them work on family farms, although their importance is even higher because their informal work is not statistically recognized as an economic contribution and is therefore not recorded (Franić and Kovačićek, 2019). Although women's employment in rural areas is generally lower than in urban areas, an increase in the employment of women (aged 20-64) in predominantly rural areas was recorded in the period from 2013 to 2017. According to the same study, women work in the informal economy to a greater extent than men, and Croatia is among the countries with the highest share of informal work by women in agriculture. Since this work is mostly socially invisible and statistically unrecorded, there is a need to statistically record informal work in the EU, especially the gender differences in the activities that are statistically most often invisible, such as domestic work and work in agriculture.

A number of studies from European countries in the last decades showed the difficult life and working conditions for women in rural areas, with the prevalence of patriarchal behaviour patterns and prejudices (causing a number of obstacles and discrimination against women), multigenerational families, the lack of adequate social services (kindergartens and homes for the elderly), limited employment opportunities, the concept of family farming based on women's unpaid work, poor transport links, and the absence of women in local governing bodies (Shortall & Bock, 2015, Copa Cogeca, 2020, Franić & Kovačićek, 2019, Fernández, 2016; Baylina, 2019, Barada et al., 2011). Recent studies confirm that rural women still face various difficulties, their roles and work are unrecognised and unpaid, and they generally do not own family property (Relja et al., 2021, Alić, 2016, Šikić Mićanović, 2014). Although the lack of kindergartens is still a problem and a barrier to finding a permanent job, recent research also indicates positive changes. Rural women are noticing positive changes: greater employment and educational opportunities, available technology, and a more egalitarian division of responsibilities related to caring for and raising children (Čurlin, 2022, Srček, 2022). Recent research in Croatia also reveals that traditional roles are still present, especially in Dalmatia and Slavonia, while in northwestern Croatia the youngest generations have moved away from some of the traditional expectations, such as staying in the multigenerational families (Srček, 2022, Relja i sur., 2021, Alić, 2016, Šikić Mićanović, 2014).

However, there is an overall lack of studies on the economic and social obstacles faced by rural women, especially in terms of employment, self-employment, and entrepreneurship. Another structural obstacle for both women and researchers is the lack of official gender-specific data, as much statistical data is not collected at all. For example, we lack important data on two groups of rural women, rural women and farm women. For example, although we know that women do most of the informal work in rural areas, this work is economically unpaid and statistically invisible, and without statistical and qualitative data, policies cannot be expected to adequately address these issues.

The aim of this paper is (1) to provide an overview of the current data available on women's positions in rural areas and agriculture on the EU level, and (2) to identify gender dimension in the Common Agricultural Policy (CAP) measures for 2023-2027 and European Maritime and Fisheries Fund policies (EMFF) and (3) to identify which type of data should be officially provided in order to make women's work recognized and valued and to help tailor future policy measures to accomplish gender equality and to address women's needs.

In the next chapters we will present data on (1) women-managed farms in period 2015-2022, (2) women-managed farms as unions or cooperatives members, (3) women-managed farms which apply socio-ecological innovative farming practices, (4) women-managed farms which diversify farm activities, (5) women-managed organic farms, (6) women's start-up businesses in rural areas, (7) women's participation in Local Action Groups, (8) women's participation in social innovation initiatives in rural areas.

Furthermore, we will briefly analyse a gender dimension in agricultural and fisheries policies in Croatia by identifying the measures aimed at gender equality in Strategic plan of the CAP for 2023-2027 and The Program for Fisheries and Aquaculture of the Republic of Croatia for the program period 2021-2027, as the two crucial documents of rural policy in Croatia.

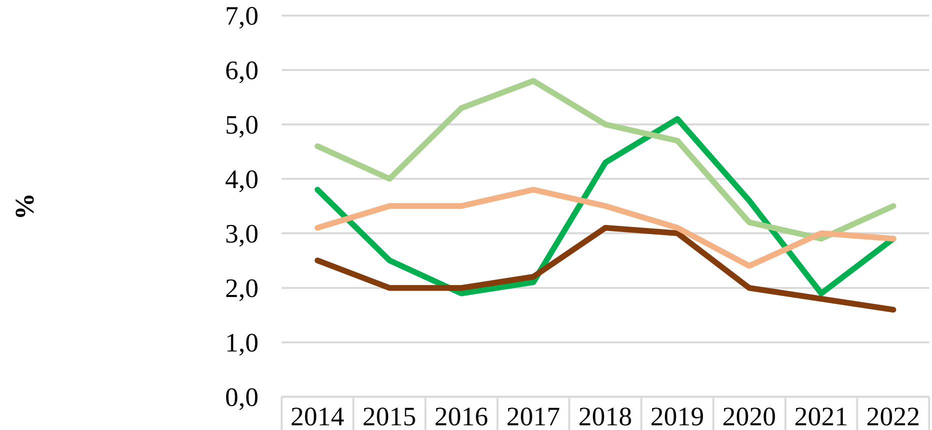
The analysis of general data sets: easily available data

In the European Union (EU), rural areas account for 83 % of the total EU land area in 2018. About 25 % of the EU population lives in rural areas, mostly an elderly population. According to Eurostat (2022), women account for 50,81 % of the population in predominantly rural regions. Females of working age (20-64 years) accounted for slightly more than half (55,8 %), older women (65 years and older) accounted for almost a quarter (24,9 %), and women under 20 years accounted for 19,3 % of the female population in predominantly rural regions. On the other hand, the proportion of the male population of working age living in predominantly rural regions of the EU was 59,3 %, and older men (65 years and older) accounted for a smaller proportion of the male population, about 20 %.

According to Eurostat (2023), 42.4% of the population lived in the predominantly rural region of Croatia in 2021. The majority, 50.9%, were women. One of the most important determinants for improving the quality of life of individuals and driving economic growth is education. In 2021, 2.3% of young people aged 18-24 were early leavers from education and training. This is below the EU average of 9.7%. Young males are more likely to leave education and training early than young females: 2.9% of young males leave education and training early. The percentage of female dropouts is lower, at only 1.6%. In rural areas, the percentage of early leavers is higher than the national average. Young men are more likely to drop out of education and training than young women. The percentage of young females in rural areas is higher than the national average, indicating that young females in rural areas are more likely to drop out of education and training (Figure 1).

The percentage of early leavers form education and training is analysed for young women and men aged 18-24. Results for men and women from rural areas are compared with the national average for 2014-2022.

Figure 1. Early leavers from education and training (18-24 years) in rural areas and national average by sex, 2014-2022



	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rural areas:	3,8	2,5	1,9	2,1	4,3	5,1	3,6	1,9	2,9
Rural areas:	4,6	4,0	5,3	5,8	5,0	4,7	3,2	2,9	3,5
National average:	2,5	2,0	2,0	2,2	3,1	3,0	2,0	1,8	1,6
National average:	3,1	3,5	3,5	3,8	3,5	3,1	2,4	3,0	2,9

Year

Source: Eurostat, 2023

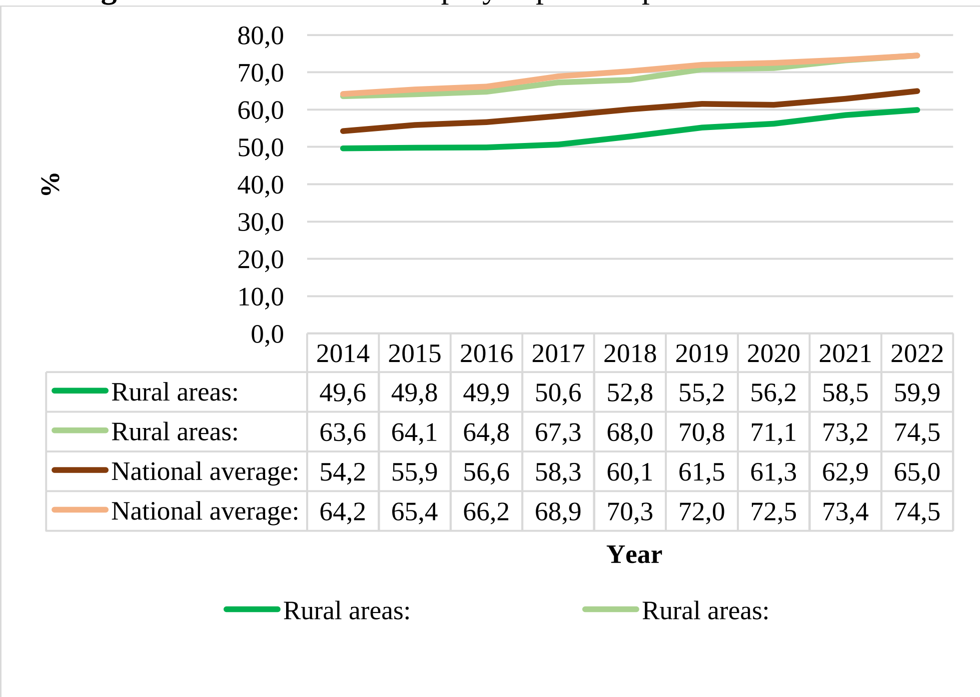
Women's employment in general, and especially in rural areas, is one of the most important indicators of women's (in)equality in society.

Data for the total population in Croatia show that 45,7 percent of the labour force in 2021 were women. Among the employed, 45,7 percent are women, while the share of women among the unemployed is 46,1 percent. Among the inactive, 58.9 percent are women. In 2021, the unemployment rate for women was 7,6 percent of women (relative to the number of employed women), while the unemployment rate for men was 7.5 percent. However, employment rate for women was 41,3%, comparing to men which was 53,6%.

Women are more educated than men, but this is not reflected in higher female employment. This is because although (in 2011-2018) 6 women were highly educated compared to 4 men (at the last official count in 2011, this percentage was 5.3 in favour of women), the share of highly educated women among the unemployed is twice the share of unemployed highly educated men. In other words, of all unemployed highly educated people, there are twice as many unemployed women as men. These data show a double inequality, because not only are women unemployed in greater numbers, but they are also better educated, which makes this inequality even greater. There are also more unemployed women at almost all lower education levels, except for those with a three-year high school diploma.

As shown in Figure 2, women's employment rates are lower than men's both on national average and in rural areas. Employment rates for women in rural areas are, on average, 15 percentage points lower than employment rates for men in rural areas. This difference is larger than the difference between male and female employment rates at the national average, which is about 10 percentage points (Figure 6). If we compare employment in cities and towns, we find that the differences between rural and urban areas are drastic, from 35% in Zagreb County up to 330 percent in eastern counties (Figure 7).

Figure 2. The number of employed persons per 1000 inhabitants



	2014	2015	2016	2017	2018	2019	2020	2021	2022
Rural areas:	49,6	49,8	49,9	50,6	52,8	55,2	56,2	58,5	59,9
Rural areas:	63,6	64,1	64,8	67,3	68,0	70,8	71,1	73,2	74,5
National average:	54,2	55,9	56,6	58,3	60,1	61,5	61,3	62,9	65,0
National average:	64,2	65,4	66,2	68,9	70,3	72,0	72,5	73,4	74,5

Source: Eurostat, 2023

While there are no overall data on rural women's employment, there are some data, particularly on agricultural employment and wages, that can be used in part as an indicator of the disparities between women and men in rural areas. For example, among those employed in legal entities for agriculture, forestry, and fishing activities, only 29.1 percent were women in 2021 (27.5 percent in 2018) (compared to 70.9 percent of men). In contrast, women's wages as a percentage of men's wages in agriculture, forestry, and fishing are 90 percent (it is an increase since it was 86.2 percent in 2018) (DZS, 2022).

In addition to the Croatian Bureau of Statistics, Eurostat provides some detailed general data, such as agricultural holdings and utilised agricultural area by training, age and sex of farm managers, labour force by sex, type of farm and size of farm, legal status of holding and working hours. Unfortunately, gender-specific data on regional structural business statistics are lacking.

The missing link – what we (do not) know about rural women's economic activity?

Rural women are a much larger population group than farm women, however non-farm rural women are often neglected in statistics and studies. There is an overall lack of data on rural women, especially non-farm women. We do not have official (or other) gender-specific data on employment, self-employment, unemployment, informal work, education, and other relevant data available by the level of urbanization (i. e. any kind of rural-urban typology). Without official data it is unlikely the rural women's issues will come to the fore at all. It is equally unlikely that the studies will be well data-supported. The lack of official data is certainly a barrier to research on relevant issues such as this.

One of the obstacles relating to data is the fact that some data is not available by gender and rural-urban axis at the same time (for example, *Towns in Statistics*, Croatian Bureau of Statistics). Furthermore, data that are gender-specific is not always analysed which makes data unreadable to wider public or even academics without conducting specific analyses, which are rather rare (Bokan, 2021).

We also tried to find official data on local action groups (LAGs), as they are one of the main actors in local rural development in EU. There are 56 local action groups (LAGs) in Croatia, out of which there are 54 of active LAGs. We present the data for the 17 of them. In these 17 LAGs there are

1.078 members, of which 461 are women (39.98%). This is data for 2022, as LAGs do not keep records of the number of female members throughout the program period (2014-2022). Furthermore, we do not know what the proportion of women is in managing positions in those LAGs.

Some data on farm women are officially collected and published. Here we will present the data on women-managed farms as unions or cooperatives members, women-managed farms which apply socio-ecological innovative farming practices, women-managed farms which diversify farm activities, women-managed farms which are organic, women’s start-up businesses in rural areas, women’s participation in Local Action Groups, women’s participation in social innovation initiatives in rural areas. Most data are not available for the 2014-2022 period.

There is no single register of cooperatives from which data would be available for all types of cooperatives. What further complicates the availability of data is the fact that cooperatives do not report changes on a regular basis. According to the Ministry of Economy and Sustainable Development of the Republic of Croatia, there are plans to merge the various data sets into a single register so that the data is compatible and easily accessible.

The Center for Cooperative Entrepreneurship kept records on cooperatives until 2015. According to the Croatian Union of Agricultural Cooperatives, the number of cooperative members in agricultural cooperatives in 2015 was 21.462, of which 8% were women-managed. However, 66% of cooperatives did not submit complete documentation, and it is not known how many women cooperative members they have. In 2015, cooperatives had 2.744 employees, 25% of whom were women, and 44% of employees could not be classified by gender because some cooperatives did not submit complete records. The data are not publicly available; they are available upon request.

According to the register of farmers (2022), there are a total of 166,430 agricultural entities. Of that number, 96.1 percent are family farms and self-sufficient family farms, and 3,9 percent are together commercial and trade companies, cooperatives, and other legal entities. The total number of women holders in all types of agricultural holdings is 49,351 women, which makes 29,1 percent (decreased comparing to 30,1% in 2018). Of the listed 166,430 agricultural holdings in 2022, women are the holders of: 30,9 percent of self-sufficient farms, 28,9 percent of family farms, 26,7 percent of trade companies, 19,99 percent of crafts. For 221 agricultural holding or 0,13% the gender of holder in not specified (Table 1).

The Croatian Bureau of Statistics does not provide gender-segregated data, so we cannot determine the share of female farm owners in the total number of farms. From the Census of Agriculture (2020), it is possible to determine the number of female farm owners working on the farm in relation to the total number of farm owners working on the farm. According to the data of the Census of Agriculture (2020), there were 38,641 female farm owners working on the farm, which represents 27.7% of the total number of female farm owners working on the farm (139,472).

Somewhat more detailed data on farm ownership is available from the Paying Agency for Agriculture, Fisheries and Rural Development (PAAFRD). The data are available for the period 2016-2022. According to the data, about 30% of women are owners of agricultural holdings. In 2018, Croatia introduced a new form of farm organization, the self-sufficient family farm, whose economic size does not exceed 3,000 euros. Data on the number of agricultural holdings and the number of women owners of agricultural holdings are presented in Table 1. Table 1 shows the percentage of female owners of different forms of organization of agricultural holding in 2016-2022.

The PAAFRD maintains data on school attendance, age, and number of members of the agricultural economy, but the data are not separated by gender.

Table 1. Women-led farms (%), 2016-2022

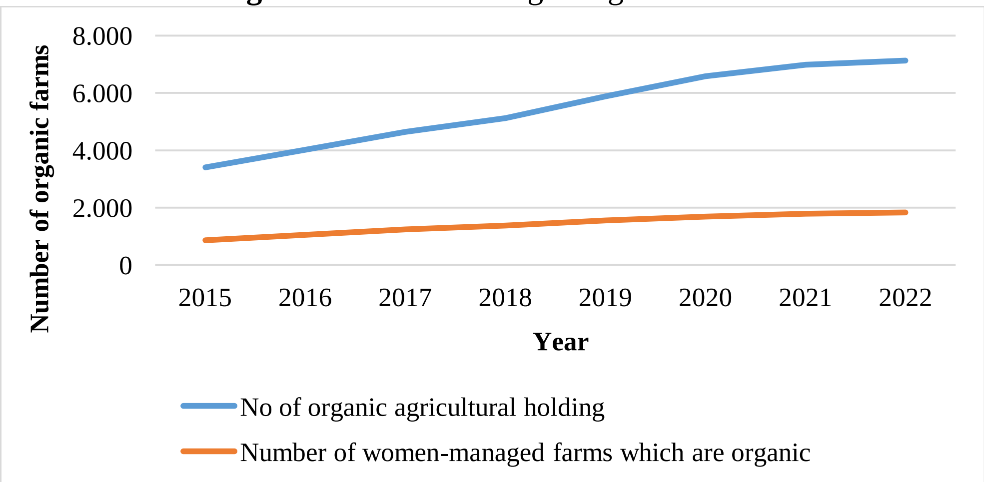
Year/Type of agricultural holding	**Women % of total owners**						
	Family farm	**Crafts**	**Company**	**Co-operatives**	**Other legal entities**	**Self-sufficient farm**	**Overall**
2016	30,77	1,77	25,33	0,16	19,90		30,27
2017	30,38	1,79	26,12	0,16	20,31		29,89
2018	30,38	1,83	26,13	0,17	20,41		29,90
2019	30,42	18,66	25,79	0,18	21,95	31,69	30,16
2020	30,14	19,36	26,13	0,18	23,26	30,82	29,93
2021	29,51	19,50	26,48	0,18	23,74	30,83	29,46
2022	28,90	19,99	26,71	0,18	23,08	30,93	29,08

Source: APPRR

The percentage of women holders of agricultural holdings is far from equal, having less than third women-led farms. The percentage is decreasing from 26 in 2016 to 25,77 in 2022 (Eurostat, 2023). However, a large proportion (67,5%) of these farms run by women are female farmers older than 55 years, which is more indicative of the age structure in agriculture than of emancipated female farmers. Only 8% of agricultural holding is run by young female farmers (25-39 years) (Eurostat, 2023). The difference is even more pronounced in commercial companies, trades and cooperatives, which indicates that in rural areas women are certainly affected to an even greater extent by the multiple, previously mentioned, social and structural obstacles to business emancipation in in the field of agriculture. It is also significant that the largest percentage of women are heads of farms with the smallest economic size of the farm, which is the group whose farm economic value is less or equal to 3,000 euros.

According to PAAFRD, in 2022 there were 7.132 organic farms in Croatia, of which 26% were managed by women (1.835). In the period 2015-2022, this percentage stagnates which means that there is not any progress in gender equality between women- and man-led organic farms in the last seven years (Figure 3).

Figure 3. Women-managed organic farms



Source: APPRR

We wanted to analyse the number of women-managed farms as unions or cooperative member, farms which apply socio-ecological innovative farming practices, farms which diversify farm activities, women's start-up business in rural areas and women's participation in social innovation initiatives in rural areas, but no data are available. It is also important to mention the fact that except the data on women-managed farms, the available data from the specific dataset is not publicly available data.

The gender dimension in recent policies

The Strategic Plan of the Common Agricultural Policy of the Republic of Croatia 2023 - 2027 does not provide for measures aimed exclusively at women. However, in Specific Objectives (SO) 7 "Attracting and supporting young farmers and other young farmers and facilitating business development in rural areas", increasing the proportion of women among young agricultural workers is set as one of the objectives. However, The Strategic Plan does not include specific measures to encourage women farmers but gives women farmers additional points (only 3-8% of the total possible points) when applying to lease agricultural land. Moreover, in SO8 ("Promote employment, growth, gender equality, including women's participation in agriculture, social inclusion and local development in rural areas, including circular bioeconomy and sustainable forestry"), gender balance in agriculture and rural areas is mentioned as one of the crucial objectives. This specific objective also lacks measures to encourage rural women. It only encourages local action groups to create local development strategies tailored to local needs and focused on women entrepreneurs. The Strategic Plan also proposes the introduction of new selection criteria for social inclusion. These new criteria refer to additional points (MP, 2022b).

The Program for Fisheries and Aquaculture of the Republic of Croatia for the program period 2021-2027 does not contain measures aimed exclusively at women, however, in all four priorities the importance of gender equality is recognized. Therefore, in accordance with the principle of partnership, representatives of gender equality bodies, relevant civil society organizations and NGOs will be involved in the preparation of the Program, public discussions and monitoring and evaluation of the Program. The Program recognizes that through its implementation it will be possible to promote women's participation, however it does not commit to do so and it does not set the measures to encourage women’s participation (MP, 2022a).

Conslusion

Considering gender equality as a core principle of the EU and the difficulties faced by women in rural areas, the European Parliament called on member states to adopt specific measures to promote women's employment under the European Agricultural Fund for Rural Development (EAFRD) (EP, 2017). However, prior to policy shaping, it is important to collect data and evidence on the issues that make the focus of the policy and having accurate, timely and detailed data on women, their work and needs is a prerequisite for creating an adequate policy. In this paper we tried to point that no adequate and committed policy to gender equality is possible if official data omits relevant information on women. There is a substantial body of social science studies on rural women throughout European countries, and it has been the main source of knowledge on rural women's lives, however those research cannot compensate for the lack of official data. Data that are officially collected are rather indicative of rural women unfavourable position in many aspects such as employment, education and informal work. However, the scope of women's unequally recognized work and obstacles which women face in work, education and family life are not adequately recognized without various and detailed statistical data, as the necessary background for any policy creating.

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Some Determinants of Changes in the Social Structure of Students of the Faculty of Agriculture and the Importance of Agro-Economics

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Abstract

The paper pointed out some determinants of changes in the social structure of students of the Faculty of Agriculture and the importance of agro-economics that it has. Research was conducted among the students of the department of agroeconomy, food technology and animal husbandry in order to analyze the most significant changes that occurred in the social structure of students, in order to point out the differences that exist in the department of agroeconomy and in other departments. Students coming from families of individual agricultural producers, when enrolling in the departments at the Faculty of Agriculture, show a drastic tendency to decrease. The financial security of students during their studies mostly depends on the funding of their parents. In all departments, the analysis showed that most students with a high school diploma are enrolled, and there was an improvement in general success, where those enrolled with excellent and very good results lead the way.

Key words: social structure, students, Faculty of Agriculture, agro-economics.

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Introduction

Social structure is one of the most important areas of sociological analysis. When we say "structure" we mean a certain relative, stable set of relationships, its constituent elements and their essential characteristics, and the mutual connections and relationships of those elements (Đorđević, 1999).

Social structure is "a multidimensional space of positions among which the population is distributed and which influence the relations of social roles and social associations" (Blau, 1977). The distribution of the population by these positions reflects the degree of differentiation of society (Konottnerus & Guan, 1977). The idea of social structure refers, in general, to the idea of an innate or organized arrangement of elements (Smelser, 1992).

Different approaches to the concept of social structure clearly show that there is no basic paradigmatic consensus. In order to illustrate these relevant differences, two different visions of social structure are usually examined: institutional and relational vision, which, without exhausting the inventory of existing approaches, point to two main directions in structural sociological thought and, more generally, in sociological theory (Bernardi et al., 2007).

The concept of social structure is very complex and can be interpreted from several aspects. Social relations for groups and individuals that enter into them are not always the same, but there are also significant differences. It is especially characteristic of relations of social inequality that exist almost between all groups and between different groups of people (Giddens, 2005). And the problem of structure and social differences is taken as the basic factor of social differentiation in the social division of labor, very often and as one of the most important due to the different positions of employees in the work process, the distribution of material goods, the distribution of social power, education, prestige, social awareness and other social characteristics (Haralambos & Holborn, 2002).

The aim of this paper is to indicate the changes that have occurred in the social structure of the students of the Faculty of Agriculture in the indicated period, to show the differences that exist in the mentioned departments and to indicate some of the most significant determinants of the changes. Starting from the current situation and the main sources of social differences when considering certain issues depending on the social structure of students, the analysis indicates that significant changes have occurred.

During the making of the work and processing of certain questions, various methods were used to indicate the social structure of the students of the Faculty of Agriculture. Based on the conducted survey, the students of the Department of Agro-Economics, Food Technology and Zootechnics gave different answers to the questions about the material situation, depending on the social situation, financial support, accommodation and nutrition, previous education and success in secondary education. The analysis showed that there are social differences among the students of Departments of the Faculty of Agriculture who were the subject of the analysis. The research used data from official statistics, data on student enrollment and official publications of the Faculty of Agriculture. The survey of students of the Faculty of Agriculture was conducted on a representative sample of 1,011 students. Statements of students, i.e. interviewing students - conversations that were conducted with them, provided a great help in the making of the paper. Likewise, relevant literature available from sociology and agro-economics, as well as those dealing with the issues that are the subject of our analysis, were used for the making of the paper.

Research results and discussions

Material position is a very complex concept that encompasses the entirety of the material conditions of life of a social group. This term is narrower compared to the term standard of living. There are several factors of financial position. However, personal income and participation in consumption represent the basic factor in the material position of a social group or an individual. Differences in the amount of wages, for example, of individual agricultural producers, employed workers, intellectuals, and craftsman are a good starting point that indicates their material position.

When it comes to the financial situation of the students of the Faculty of Agriculture of the aforementioned departments, we must take into account, first of all, the financial situation of the family from which the student comes and the various forms of funds that are intended for them in order to reduce the differences in the education process of students of our faculty (Živković et al., 2008).

In order to monitor the changes that occur in the social structure of students, we first of all started from the consideration of social origin in the departments of agro-economics, food technology and zootechnics.

At the agro-economics department, out of the total number of students enrolled in the academic year 1975/76, the largest share of enrolled students comes from families of individual agricultural producers, and their share is 30%. From the total number of students enrolled in the 2005/06 academic year the largest percentage of enrolled students came from families of intellectuals, 51.87%, while students from families of individual agricultural producers participated with 6.42%. Based on research conducted among students enrolled in the aforementioned department in the academic year 2022/23, the largest share of enrolled students comes from families that have completed high school, 56.82%, and the least number of students whose parents are farmers, 9.09%.

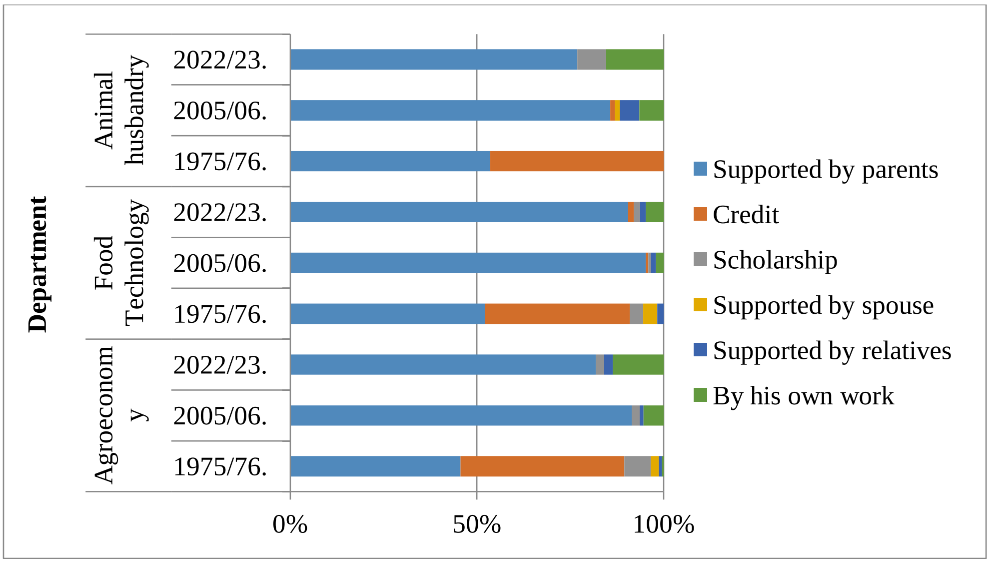
At the Department of Food Technology, students come from families of intellectuals and their share is 51.7% in the academic year 1975/76, 2005/06 44.3%, and in 2022/23 that trend continues, because the largest share of students from families of intellectuals is 42.86%.

At the Department of Animal Husbandry (zootechnics) in the 1975/76 academic year the participation of students from families of employed workers recorded a share of 43.3%. The largest share of students comes from families where parents have a high school education, 38.96% in the 2005/06 academic year, and the research in 2022/23 shows that the largest share of students whose parents have completed high school is 46.15%.

Therefore, the data analysis shows that there were significant changes in the social structure of students in the indicated period in the departments that were the subject of the work. Unequal living conditions of families enable unequal opportunities for getting an education. That is why the social opportunity of a student of an individual agricultural producer and an employed worker to become an engineer of food technology, animal husbandry, that is, graduated agroeconomists do not have the same opportunities as students whose origin is a family of intellectuals.

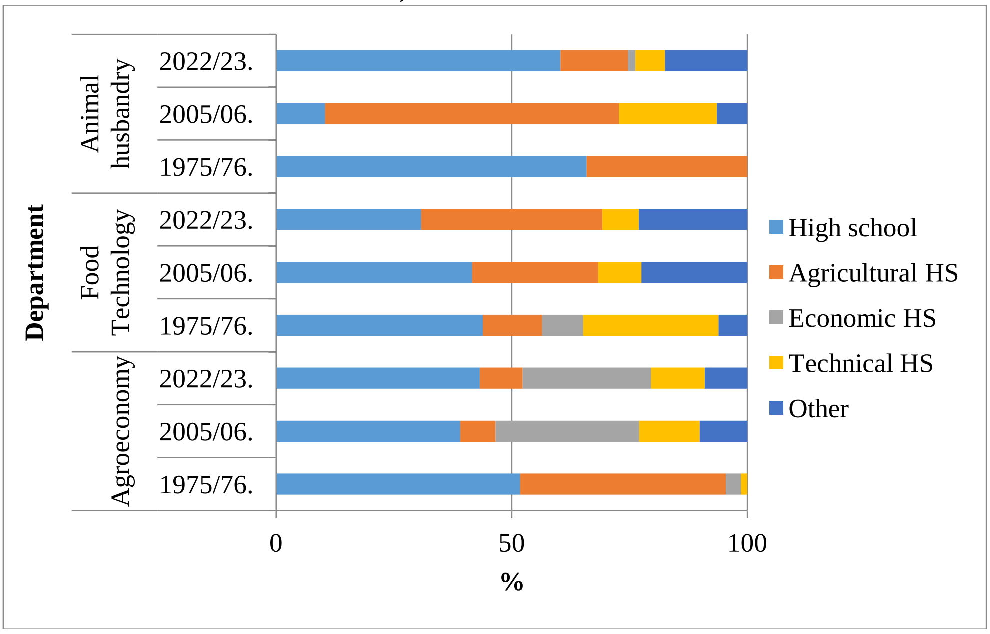
The main source of financial support for students is determined by the place of accommodation and way of nutrition. In the process of studying, students have different sources of income. For the total number of surveyed students of all departments during the academic year 1975/76, 2005/06 and 2022/23, the main source of income comes from parents, and the participation of other sources of income is significantly smaller (Chart 1).

Chart 1. Structure of student financial support, 1975/76, 2005/06 and 2022/23



Housing and inadequate housing conditions have a negative impact on studying. Unfavorable living conditions can indirectly affect the reduction of several student activities. Having favorable housing conditions is satisfying one basic need for housing and satisfying the secondary needs of students. During their studies, students can be accommodated: in a student dormitory, with parents, relatives, tenants, etc. Student accommodation is an important factor in successful studies. The structure of students according to the place of accommodation indicates that enrolled students from cities and municipalities originating from the interior of Serbia are mostly housed in student dormitories, privately and with relatives. In all three departments, more than half are students from families of intellectuals who are staying with their parents during their studies. Therefore, the different types of student accommodation indicate that the housing conditions are also different. This means that students staying with their parents mostly belong to families of intellectuals, they have better conditions for housing, nutrition, and more security, which should stimulate them to achieve better results during their studies. Seen as a whole, the largest number of students eat in student canteens and at their parents' house. The favorable prices of food in student canteens, which are incomparably lower than the prices in other types of restorants, influence that a considerable number of students opt for this type of nutrition. These are not the only forms of nutrition because a certain number of students meet their nutritional needs by eating at other restaurants, at relatives' or preparing food themselves.

Chart 2. Structure of students according to previous school education, 1975/76, 2005/06 and 2022/23

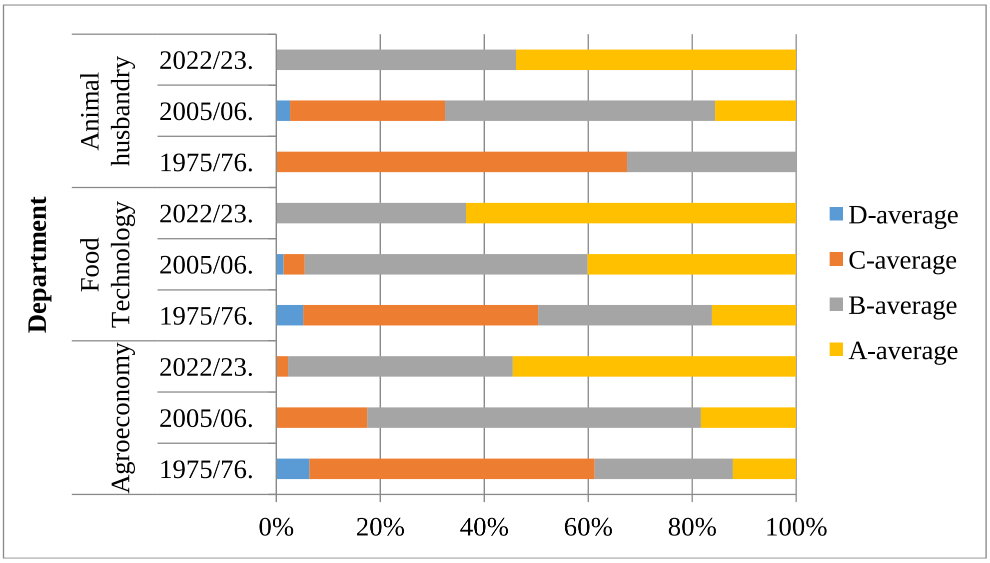


Analysis of enrolled students according to previous school education 1975/76 showed that the largest number of students have completed high school in all departments, about 50%. In academic year 2005/06, the majority of students enrolled in the agro-economics department were those who had completed high school and economic school. In food technology, there were the most enrolled students with completed high school and agricultural high school, and in the department of animal husbandry, about 60% of students enrolled with completed agricultural high school. Research conducted in 2022/23 shows that agricultural economics students mostly have completed high school or high school of economics, in the department of food technology the largest share of students with completed high school of agriculture is 38.46%, and 60.32% of students enrolled in zootechnics with completed high school (Chart 2).

Based on the analysis of students enrolled in the academic year 1975/76, the largest number of enrolled students had C-average success, around 53%.

In the 2005/06 school year there was an improvement in the success of enrolled students, where the largest share had a B-average success, 56.81%, and in the academic year 2022/23, the most enrolled students are with A or B-average results. Therefore, in the mentioned period, there was an improvement in the success of enrolled students (Chart 3).

Chart 3. Structure of students according to success, year 1975/76, 2005/06 and 2022/23



Importance of agro-economic science and profession

Agroeconomic science and profession have an important role in the development of agriculture and the overall economy in our country. The role of the development of agro-economic thought at higher education and scientific institutions in Serbia is very important. Agroeconomic science and profession have an increasingly important role today. The development of agro-economic thought in Serbia began with the founding of the University of Belgrade in 1905, when an agricultural department was established as part of the Faculty of Philosophy, which institutionalized the specialty of agro-economic education (Tomić & Ševarlić, 2009).

Since the establishment of the department for agro-economics, until today, the opinion about the need for agro-economic profession, as an educational profile, as one of the significant courses at the Faculty of Agriculture, which is increasingly emerging as a modern, attractive and sought-after profession, has matured. So far, 3,400 students have graduated at all levels of study, from undergraduate to doctoral.

The market as the basic arbiter in the economy showed and increasingly shows the need for agro-economics as a science and profession. With reason, the question arises as to where agroeconomists can find their place, especially today, in the process of transition of our economy and society (Pejanović & Tica, 2002). It is therefore a broad reproduction chain in which an agroeconomist is necessary, bearing in mind that the agricultural sector is a development opportunity not only for agriculture, but also for the economy of our society in general, which creates opportunities for the application of agroeconomic science and profession.

Agricultural production is the main activity in rural areas, so it is to be expected that a significant part of students comes from them. However, according to research conducted in 2014 and 2015, the territorial distribution of students was relatively balanced, as 45.8% and 53.4% of students from urban areas and 54.2% and 46.6% of students from rural areas enrolled in agroeconomics. Most students were from the Belgrade (39.2% and 48.3%), followed by the South Banat, Srem, Rasin, Zlatibor and Mačva districts, while the other districts were represented to a lesser extent.

As for the previous education of enrolled students, about a quarter come from high schools, 25.0% in the 2014/15 academic year, 24.6% in 2015/16 (Nikolić & Jovanović, 2015), and in 2022/23 similar tendencies are observed.

Based on all the above, agroeconomic science and profession will continue to play a significant role in the process of agroeconomist education in the coming period. Several relevant facts indicate that agriculture as a development sector with its resources, production and economic effects occupies a significant place in the economic structure of Serbia (Marković & Babović, 1998). The times we live in require and will require the role of an agroeconomist who will have a notable place in the field of agriculture and the food industry of our country.

Conclusion

Research shows significant changes in the social structure of students that occurred in the period 1975/76, 2005/06 and 2022/23 for students of the Agricultural Faculty of Agro-Economics, Food Technology and Animal Husbandry. Students who come from families of employed workers, individual agricultural producers, intellectuals, etc. study at the Faculty of

Agriculture. The social structure of students indicates the differences that exist both in the Department of Agro-Economics and between the mentioned departments.

Questions that considered the social structure of students over a period of 48 years show that there have been significant structural changes, which were analyzed and stated in the research. The most frequent and pronounced changes occurred among students originating from the families of individual agricultural producers, where their participation in the total number of enrolled students decreased considerably. Sources of students' financial security show that they are mostly provided by their parents. Most of the students are accommodated privately. Analyzes have shown that primarily students who have completed high school, secondary agricultural and economic school are admitted to the faculty. When looking at the enrolled students according to the achieved success, there was an improvement in the success of the enrolled students, where there are more and more of them with excellent and very good results.

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