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PREFACE

“Village and agriculture“ proceedings include selected scientific articles that were entirely presented at the International scientific conference „Village and agriculture“ held from September 29 until September 30 2023 at the Faculty of Agriculture of Bijeljina University.

Papers of the authors from the Republic of Srpska, Bosnia and Herzegovina, neighbouring countries as well as closer and wider surroundings that Faculty of agriculture has achieved scientific, professional and technical cooperation are presented in the proceedings.

Through two sections and an introductory panel lecture, the proceedings address a wide scientific and professional audience and are actually aimed at all segments of agricultural production, agricultural economics and rural development as life in the countryside today.

The publisher and editors are not responsible for the content of the published articles and the opinions expressed in them, because they represent the point of view of the paper's author. The editorial office owes a special thank to the organizing committee of the conference, as well as to all participants from the country and abroad.

A number of scientific and teaching institutions from the country and abroad participated in the coorganization of the conference, and its realization was carried out in cooperation with the project GROWTH - *Greening Relevance in Operations in Western – Balkans Tertiary – Education Habitats*.

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Editors:

Prof. Boro Krstić, Ph.D

Prof. Milivoje Ćosić, Ph.D

Prof. Jean Vasile Andrei, Ph.D

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APPLICATION OF THE INTERNET OF THINGS IN AGRICULTURE

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Abstract

The development of information technologies expands the possibilities for economic growth and the development of the digital economy. A new direction in the agricultural sector such as smart (precision) agriculture with technologies such as the Internet of Things, computer vision and artificial intelligence can improve agricultural efficiency, transparency, profitability and equity for farmers in low- and middle-income countries. This paper presents an overview of the main challenges in agriculture at the current stage of development, an analysis of the perspectives of using the Internet of Things in the agro-industrial complex, an examination of the main technologies and drivers of development, as well as an analysis of the barriers that hinder the spread of digital technologies in agriculture. In other words, the aim of the paper is to analyze the current development of digital technologies in agriculture in general, and especially in the development of the Internet of Things – IoT.

Key words: Smart (precision) agriculture, digital technology, information technology, internet of things.

Introduction

The industrial revolution took place in stages, and the first industrial revolution used water and steam power to mechanize production. The second was based on the use of electricity for mass production. The third stage is the use of electronics and information technology to automate production.

Today, the Fourth Industrial Revolution is built on the Third, the digital revolution that has emerged since the middle of the last century. It is characterized by the merging of technologies, which leads to the blurring of the boundaries between the physical, digital and biological spheres.

The concept of Industry 4.0 is based, above all, on the use of the Internet and information (IT) and communication technologies. In this regard, with the combination of modern information technology and traditional agriculture, the era of agriculture 4.0 began, which takes the form of smart or precise agriculture. This concept transforms traditional agriculture into a modern one, based on innovation and high technologies, such as artificial intelligence, robotics, machine learning. These are intelligent systems that enable the prediction of requirements from the environment, which are often complex and unknown (Karadžić & Babić, 2005).

For developed countries, the agriculture and industrial sectors continue to face challenges such as the demands for increased productivity and food production, as well as the development of employment opportunities for people from poor and rural areas. The agricultural sector is affected by economic trends, as well as rapid changes. Various studies have shown that there is a strong demand for IT used to solve problems as well as to improve and increase agricultural productivity and marketing. But the interest of IT for agriculture has not been fully exploited. The introduction of information technology in the rural and agricultural sector is quite slow compared to other economic sectors where modern information technology is being incorporated at a faster rate.

The development of information technologies has had a significant impact on the agriculture of highly industrialized countries. Over the past few years, a number of new technologies and industry-specific applications have emerged, including the increasing agricultural application of mobile communication devices and technologies. Providing Internet access for every individual, especially for those living in rural areas (e-Rural), is among the first priorities of the European Union's research and development program for information society technologies (Szilágyi, 2012). According to research development and application trends, as well as predictions and expectations, these technologies and services will become widely applied tools to enhance business innovation and support business management.

The Food and Agriculture Organization of the United Nations (FAO) reports that, compared to 2010 levels, global food production needs to increase by 70% before 2050 to feed the growing world population, which is expected to reach between 9.4 and 10.2 billion (FAO, 2009). We need to achieve this goal despite the fact that the amount of arable land is not increasing, diets are changing, demand for water is increasing, the climate is changing, and both the environment and soil health are under pressure. It should also be noted that the majority of the population is rural, and more than 70% of farmers are small producers (Lowder et al., 2016).

The challenge of growing agriculture in any country is great, not only to meet the increased demand for food, but also to reduce hunger and malnutrition. The issues are therefore complicated because the growth of the agricultural industry, taking into account the preservation of the environment, should take place in a sustainable manner. In the current situation, farmers face smaller profit margins, the costs of many inputs such as fertilizers and fuels have risen, while the prices of products have been fairly stable, or fallen. Lowder et al., (2016) states that of the total number of farms (570 million) in the world, 72% belong to farmers who cultivate land on less than 1 ha of land, whose products are for their own needs. The fact that agriculture is a significant driver of economic growth and is key to the total gross domestic product (Mellor, 2017), farmers must invest in their business, produce and market.

Therefore, the introduction of high technologies for the processing of big data, the use of unmanned vehicles, self-driving vehicles, the use of sensors can modify agricultural farms into smart farms. Therefore, the aim of the paper is to point out the importance of introducing new technologies in the agricultural sector.

What is the Internet of Things - IoT?

The Internet of Things is a new and currently the fastest developing area of information technology. Many authors state that IoT is a technological revolution, which represents the future of computing and communication. The development of IoT depends on technical innovations in numerous areas, from wireless to nano-technology.

The Internet of things (IoT) is defined in many ways. The shortest definition is IoT represents a network that connects smart things. That is, it forms a platform that connects devices, objects, and people via wired and wireless networks, and with the obtained data, analyzes can be performed with or without human activity.

Radić et al., (2022) define IoT as a set of technologies in which physical objects interact with the digital world. This enables the connection of a large number of users, devices, services and applications to the Internet, which implies the exchange of data directly or indirectly. Also, according to the same authors, IoT devices include: sensors, actuators, modules, microcontrollers and microcomputers. The basis of starting IoT is computer components and web and/or mobile applications, with the help of which data from the physical world is collected directly from sensors or communication devices to the software platform, for further use and use of the obtained data.

In general, the goal of IoT is the integration of the virtual world with the physical world, using the Internet as a communication medium. The Internet of Things is practically feasible with several existing technologies, such as wireless sensor networks, radio frequency identification, cloud computing, and end-user applications (Figure 1).

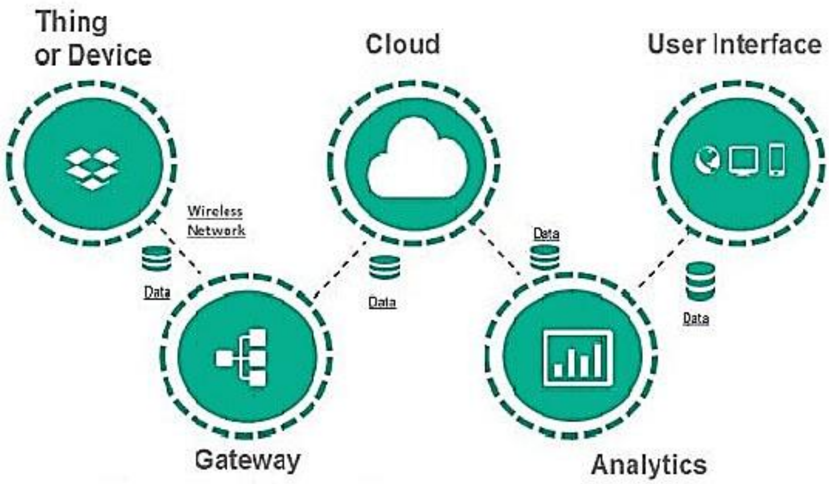

Figure 1. Major components of IoT (https://www.rfpage.com/what-are-the-major-components-of-internet-of-things/ - accessed on 06/28/2023)

Digital technologies and IoT in agriculture

The creation and development of digital technology based on the Internet of Things (IoT) has changed almost every industry, including agriculture (Bonneau and Copigneaux, 2017). The use of data in agriculture leads to the development of a new direction in agriculture, which is called smart or precision agriculture. According to the available literature, the definition of smart agriculture refers to a management concept focused on providing infrastructure to the agricultural industry to use advanced technology – including big data, cloud and Internet of Things – to monitor, observe, automate and analyze operations, as well as software and sensors. Smart agriculture is gaining importance due to the combination of a growing global population, increasing demand for higher crop yields, the need for efficient use of natural resources, monitoring of climate conditions and the increasing use of modern information and communication technologies.

Agricultural farms have historically not used high technologies, but by 2025 they are planned to significantly increase their use to millions of gadgets. The reason for this is the increasing urbanization of the world population, where it is predicted that by 2050, 70% of the population will be urban compared to the current situation, which is 49% (UN, 2018). This implies an increase in the demand for food, and food production should double by 2050 (UN, 2009).

The Internet of Things (IoT) is a key technology in smart agriculture as it enables networking and data exchange between sensors and other devices, which adds value to information obtained through automated processing, analysis and access, enabling faster and more cost-effective farm management (Rechkin et al., 2019).

The use of precision agriculture technologies based on the Internet of Things is the consequence of increasing yields on a large scale. For the first time in history, it became possible to obtain information about any agricultural object, create an accurate mathematical algorithm of actions and make a forecast of the results. The main innovative solutions that characterize the concept of intelligent agriculture are: precise agricultural production; unmanned land vehicles; autonomous wireless sensors; simulation of digital management; cloud technologies.

According to Radić and Radić (2021), the basic digital technologies in agriculture are the so-called sensor technologies, such as temperature, humidity and soil scanners, field weather stations, yield mapping, satellite, drone or aircraft imagery, and the Internet of Things.

Thanks to the development of IoT, with the help of digital technologies, it enables the monitoring and collection of a large number of data (parameters) in real time on large areas, in all climate and weather conditions, 24 hours a day, such as the appearance of weeds, pests, diseases, monitoring of dangerous weather conditions or soil conditions. Such progress leads to the reduction and adequate use of resources, including fertilizers or protective equipment. Radić et al., (2022) state that the data obtained with the help of precision agriculture and robotics enable optimal sowing, fertilizing and crop protection, precise irrigation, precise weed control and automated harvesting, statistical processing and data analysis, which allows correct decisions to be made based on data from sensors and with the help of other technologies (big data, cloud computing, blockchain and artificial intelligence).

In developed countries, the collection and processing of data, including the practical use of high-tech innovations, is carried out using telecommunication and satellite navigation systems. Among the adopted solutions, we can mention pest control systems, planting and replacement of heavy tractors, soil compaction, precise fertilization systems, irrigation. Using IoT to monitor water use for optimal plant growth and determine soil moisture and nutrient content is the most common application for IoT (Kurdyumov and Korolev, 2020). According to Rechkin et al., (2019) monitoring the physical health of plants and soil is one application, but it can lead to a large return on investment for industrial farmers through the use of sensor technology.

Processing and analysis of the obtained main parameters allows solving the problem of working time in the field, including the yield of arable land. This allows farmers to obtain parameters, such as the amount of fertilizer, food, water in the soil and planted seeds, the temperature of stored products, the status of agricultural machinery and equipment in use and much more (Gorbunova et al., 2019).

Thanks to the use of the Internet of Things, the agricultural economy becomes manageable, that is, decisions are made in real time, reducing uncertainty and inefficiency, and therefore the negative impact on the environment. The emergence of "smart" devices allows control of crop productivity, taking into account changes in the growing environment. The introduction of IoT in plant production automates the control of climate parameters, soil characteristics, minimizes human participation in the technological operations of product production (Gorbunova et al., 2019).

Informacioni sistemi i neuronske mreže analiziraju više događaja i poboljšavaju poslovnu efikasnost. Generalno, farmeri se suočavaju sa dva glavna zadatka: da maksimiziraju prihod i smanje troškove, uz održavanje visokog kvaliteta proizvoda i zaštite životne sredine. U poljoprivrednom preduzeću se kreira informacioni oblak za razmenu podataka analitičkih i administrativnih struktura u non-stop režimu IT sistema, a takav oblak je neophodan za razvoj IoT (Gázquez et al., 2016).

The basic groups of technologies and supporting equipment for the proper functioning of smart agriculture, according to many studies, are:

1. Information systems

With the help of information systems and additional equipment, such as various devices, sensors, drones, etc., data is collected, processed, stored and distributed.

2. Precision agriculture

Precision agriculture involves looking at spatial and temporal parameters in order to form the most efficient agricultural production strategy while reducing inputs and reducing environmental pollution. In order for the aforementioned to work, it is necessary to implement and use technologies such as GPS (Global Positioning System), GNSS (Global Navigation Satellite System), analysis of digital and hyperspectral images and terrain recordings with the help of cameras mounted on unmanned aircraft - drones and satellites, creation of terrain maps showing all relevant factors that can be measured (for example: crop yield, terrain characteristics, soil moisture, chemical elements).

3. Agricultural automation and robotics

It is about the process of applying robotics, automated control and artificial intelligence at all levels of agricultural production. These processes significantly increase productivity, precision in work, as well as the economy of agricultural production.

GPS (Global Positioning System)

The implementation of precision agriculture or location-specific agriculture becomes possible through the use of GPS ("Global Positioning System") technology. As IT engineers explain, GPS technology combined with the GPS-server.net tracking system enables real-time data collection with accurate position information, which leads to efficient manipulation and analysis of the collected data. GPS - server.net service can be used for precision farming, field planning, yield mapping and tractor guidance. GPS works in any weather conditions, anywhere in the world, 24 hours a day, with no subscription or setup fees.

The accuracy and benefits of using GPS allow farmers to create farm maps with precise acreage, road locations and distances between points of interest, collect soil samples or monitor crop conditions. GPS receivers collect location information to map field boundaries, roads, irrigation systems, and crop problem areas such as weeds or disease. Special devices equipped with GPS devices are able to precisely distribute the swaths on the field, applying chemicals only where it is needed, minimizing the chemical ratio, reducing the number of required chemicals, thereby contributing to the environment and more precise use of materials.

GIS (Geographic Information System)

Geographic Information System is a system for collecting, memorizing, checking, handling, analyzing and displaying data that are spatially related to the Earth. It is a technology that combines hardware, software and data. Data can represent almost anything imaginable as long as it has a geographic component. Satellites, drones and manned aircraft are used for remote sensing, which is the collection of information about the earth's surface by scanning from high altitudes. Landsat 8, is an observation satellite (a joint effort of the United States Government Science USGS and NASA) that orbits the Earth every 16 days. It includes 9 bands of the visible light spectrum that can be used to calculate factors such as plant diseases, nutrient deficiencies, insects or crop moisture excess and deficiency. It also captures thermal infrared radiation (TIR) that is beyond the range of human vision. Depending on the surface temperature, the intensity of the wavelengths emitted by different types of vegetation varies, managing the consumption of irrigation water, detecting plant diseases or evaluating the ripeness of fruits.

A **B**

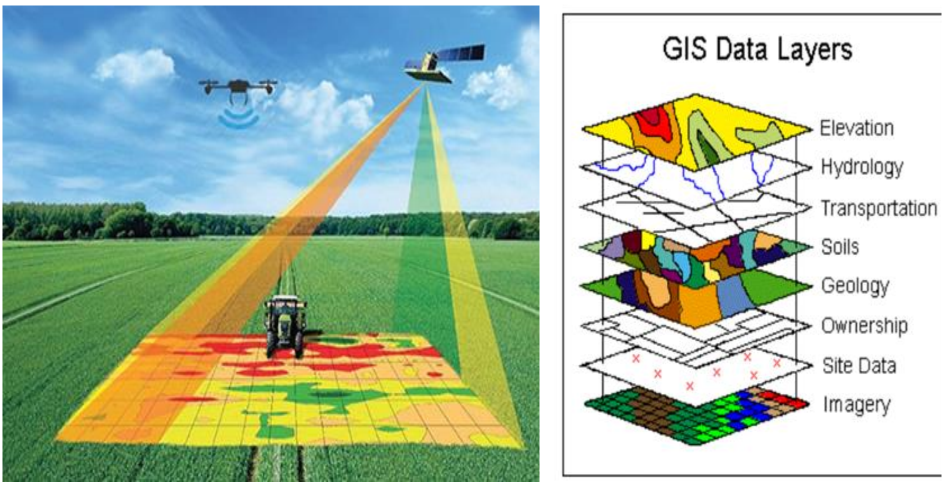

Figure 2. The success of precision agriculture is based on the accuracy of the collected data, in two ways (Hassan, 2018)

A. it involves the use of multifunctional imaginary devices equipped with remote sensing platforms, such as satellites, agricultural planes, balloons and drones,

B. it involves different types of sensors – the collected data is identified with precise location information using GPS and GIS devices, so that treatment specific to that location can subsequently be provided.

Sensors

Modern sensors are widely used in various applications such as robotics, navigation, automation, remote sensing, underwater imaging, etc., and in recent years, sensors with advanced techniques such as artificial intelligence (AI) are playing a significant role in the field of remote sensing and smart agriculture. AI-enabled sensors work as smart sensors, and additionally, the emergence of the Internet of Things has resulted in very useful tools in the field of agriculture by making available various types of sensor-based equipment and devices (Plotnikov, 2019).

Sensors are most commonly used in numerous applications ranging from measuring body parameters to automated driving. Furthermore, sensors play a key role in performing detection and vision-related tasks in all modern science, engineering and technology applications where computer vision dominates (Hassan et al., 2020). An interesting emerging domain using smart sensors is the Internet of Things (IoT) which deals with wireless networks and distributed sensors to hear data in real time and produce specific results of interest through appropriate processing (Shafi et al., 2019). In IoT-based devices, sensors and artificial intelligence (AI) are the most important elements that make these devices sensible and intelligent. In fact, due to the role of artificial intelligence, sensors act as smart sensors and find effective use for various applications, such as general environmental monitoring (Sishodia et al., 2020); monitoring of a certain number of environmental factors; weather forecast (Di Napoli et al., 2020); satellite imaging (Zhu et al., 2018) and its use; applications based on remote sensing (Addabbo et al., 2016); monitoring hazardous events such as landslide detection (Di Napoli et al., 2020); self-driving cars; healthcare and so on.

Modern agriculture using advanced technologies such as artificial intelligence and smart sensors can produce increased yields with appropriate crop quality assessment (Doshi et al., 2019), crop classification and soil moisture measurement (Lu et al., 2020). Zhang and Wei (2020) state that smart sensors are being used in the agricultural sector by incorporating modern sensors, advanced AI techniques, in soil health monitoring systems, sensor applications in animal husbandry and crop yield analysis. The role of smart sensors is extremely important in agriculture and pharmaceuticals where not only productivity is increased, but sustainable growth is also achieved. Smart sensors and the Internet of Things are changing conventional farming practices into smart agriculture that is helping to empower farmers around the world.

Today, there are a large number of sensors that measure various parameters very accurately using certain methods:

1. Location sensors - determine latitude, longitude and altitude with the help of GPS satellites.
2. Optical sensors - use light to measure soil properties. They are placed on satellites, drones or robots to determine the content of clay, organic matter and moisture in the soil.

3. Electrochemical sensors - sensors help collect soil chemical data by detecting specific ions in the soil. They provide information in the form of soil pH and nutrient levels.
4. Mechanical sensors - These sensors are used to measure soil compaction or mechanical resistance.
5. Dielectric Soil Moisture Sensors - These sensors measure moisture levels by measuring the dielectric constant of the soil
6. Air flow sensors - These sensors are used to measure air permeability. They are used in fixed position or in mobile mode.
7. Sensors for monitoring animal health and activity
8. Temperature sensors
9. Sensors for morphological conditions and analyzes of plants, etc

Agriculture drones

The use of drones in the agricultural sector has led to the improvement of many agricultural practices. When it comes to precision agricultural production, the use of drones has become a basic measure of production, which takes place by recording and collecting data on real and current crop conditions. Based on this data, producers can plan and organize their sowing/planting, as well as the treatments needed in order to obtain high stable yields.

From data collected by drones, farmers can derive insights related to plant health indices, plant counts and yield predictions, plant height measurements, canopy cover mapping, stock measurements, chlorophyll measurements, wheat nitrogen content, drainage mapping, weed pressure mapping, and so on.

According to the available literature, there are two types of drones – aerial drones and ground-based drones used in agriculture for crop health assessment, crop monitoring, pesticide spraying, irrigation, planting and field analysis.

All large investments in agriculture require intensive production and large areas in order to make the investment pay off. This is also the case with drones, which in order to be profitable, must be constantly in use and perform as many operations as possible during the season.

Operations that can be performed with the help of drones are:

1. Monitoring the health status of plants
2. Monitoring of conditions on the ground
3. Sowing and planting
4. Application in plant protection
5. Use for security purposes
6. Pollination

7. Irrigation

In addition to the many advantages offered by the use of drones, it is very important to understand their limitations and functions, since drones, like other precision farming equipment, are extremely expensive.

The introduction of big data technology, the use of unmanned vehicles, self-driving vehicles, the use of sensors can modify agricultural farms into smart farms.

However, Radić et al., (2022) explains that there are certain obstacles in the implementation of technologies in smart agriculture: fragmented market, coverage and connection (connection), large investments, fear of new technologies, untrained personnel and undeveloped standards.

The key advantages and main reasons for using IoT in agriculture are:

1. The ability to collect, analyze and create conditions for continuous planning of agricultural production
2. Monitoring, development and improvement of agricultural production
3. Digitized parcels and monitoring of execution of operations
4. Centralization of documentation.
5. More effective management of development and ongoing agricultural policy, etc.

Conclusion

Agriculture 4.0 creates dynamic communication systems that increase productivity, save resources and materials, and optimize costs, through the automation and digitization of a large number of processes in agriculture.

The agricultural sector must overcome challenges such as climate change, environmental pollution and the production of healthy food. In order to increase productivity, it is necessary to use innovative technology and the Internet of Things.

IoT-related technologies have a major impact on precision or smart agriculture, as well as the global economy. The integration of products, knowledge and services through IoT maximizes the scope of productivity, product quality, business profits and time savings.

The application of new information technologies enables the timely performance of work in agriculture, as well as the prevention of problems. It is also significant that, thanks to precise data, accurate and precise measures and methods can be calculated, which results in significant savings, and enables the increase and preservation of yields.

The current use of information technologies in agriculture in our area is modest and is explained by economic arguments. Precision technology and smart solutions in agriculture contribute to the improvement and increase of yields, but the main contribution of digitization in agro sectors is the management of natural resources in a sustainable way.

Digital agriculture has an enviable potential to increase economic contribution through expanding market opportunities, agricultural productivity and cost efficiency. There are also environmental benefits through optimized resource use and adaptation to climate change, as well as social and cultural benefits through increased communication and inclusiveness.

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AGROECOLOGY - TRANSITION TO SUSTAINABLE AGRICULTURAL AND FOOD SYSTEMS

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Abstract

The modern concept of agroecology implies the integration of research, education, actions and changes that bring sustainability to all parts of the food system. The approach is based on ecological thinking and a holistic understanding of the sustainability of the food system, which means that agroecology is simultaneously a science and a practice and a social movement, and that all three elements are needed together to initiate transformation.
Agroecology in Bosnia and Herzegovina (BIH) is generally not recognized as a concept of a sustainable food system. Although many agro-ecological measures are foreseen in the strategic framework, there are no such measures in the relevant regulation, and therefore there is no support for those measures. Agroecology is recognized as a science at some agricultural faculties. There are also international projects and research teams that could define the modern concept of the introduction and development of agroecology in domestic policies, but due to the weak integration of science and the agricultural practice and the lack of understanding of the importance of the concept of agroecology and the transformation of agriculture towards sustainable agricultural systems at the level of government institutions, the current situation is not encouraging.
Agricultural producers in BIH are generally not familiar with the concept of agroecology or the schemes of agro-ecological measures. The majority of them would be ready to accept the agro-ecological concept on a wider territorial level with appropriate advising and training. An agroecological school program is active in BIH based on the participation of the Alica Foundation in the international forum for agroecology and the Bilim digital platform.

Key words: Agro-ecological measures, TAPE, school of agroecology, Bilim.

Introduction

According to the definition of the Food and Agriculture Organization of the United Nations (FAO, 2018a), agroecology is an integrated approach that simultaneously applies ecological and social concepts and principles in the creation and management of agricultural and food systems. This approach implies knowing and using the interactions between plants, animals, people and the environment, including social aspects for a sustainable and just food system.

Agroecology as a practice has been developed gradually in recent decades, but only recently has it been more widely promoted through various movements, organizations and institutions, farmer groups and schools of agroecology. Although agroecology is not yet clearly part of the legislation of the European Union (EU), it is recognized as a way to improve the ecological characteristics of production through a system of agro-ecological measures.

In the 80s of the last century (Gliessman, 2018), agroecology was seen as a form of resistance or an alternative to existing food production systems based on monocultures, the industrialization of all segments of food production, processing and distribution, and the increased control and dominance of corporations over the food system. At the very beginning, agroecology was defined as the application of ecological concepts and principles in the design and management of sustainable agroecosystems at the farm level, i.e., farm agroecosystem, or simply the science of sustainable agriculture (Altieri, 1995; Gliessman, 2007, 2013). This approach nevertheless encouraged farmers to change the practices of conventional industrial agriculture, especially in terms of the use of raw materials and chemicals based on fossil fuels and fertilizers, towards certified organic production systems. When it became evident that replacing raw materials alone was not enough to overcome the problems in monoculture systems, farmers began to bring diversity back to their farms. Thus began the process of building agricultural systems based on system resistance to problems. By the end of the 90s, agroecology was already defined as the ecology of the entire food chain (Francis et al., 2003) and the agroecosystem was not only observed at the farm level, but included other aspects and participants in the food system. This change led to an emphasis on the need to re-establish a close relationship between producers and consumers, that is, to reduce negative phenomena between them (Gliessman, 2007).

In order to change the overall food system, it is necessary to provide both political and economic focus (IPES-Food, 2016). This realization led to the further development of the definition of agroecology, which observes it through the integration of research, education, actions and changes that bring sustainability to all parts of the food system (ecological, economic and social aspects). Thus, agroecology is transdisciplinary, participatory and action-oriented because it confronts the economic and political structures of the existing industrial food system with alternative social structures and political actions. The approach is based on ecological thinking and a holistic understanding of the sustainability of the food system, which means that agroecology is simultaneously a science and a practice and a social movement, and that all three elements are needed together to initiate the transformation of the food system (Gliessman, 2018).

In the current agricultural policies in Bosnia and Herzegovina (BIH), EU agro-ecological measures are not in force. Some of the agro-ecological measures are determined by strategic documents, but they are not applied or the available funds for their implementation are modest, which does not achieve the desired or necessary impact on sustainable development. On the other hand, BIH have undertaken to harmonize the agricultural policy and the rural development policy with the corresponding policies at the EU level (Mićić, 2019). Also, BiH is obliged to apply the United Nations Convention on Biodiversity (CBD) and other international agreements and conventions that protect the environment and define measures to achieve the goals of sustainable development (CBD-UNDP, 2019).

This paper provides an overview of the development of the concept of agroecology in the world with a special focus on Europe and BIH, as well as an analysis of the possibility of transition to agroecology based on the analysis of the regulatory framework and own research conducted in selected territories in BIH.

The concept of agroecology

Industrial agricultural and food systems have succeeded in providing large quantities of food on global markets. However, these systems imply high external inputs and intensive use of resources, which results in high consumption of resources (massive deforestation, water scarcity, loss of biodiversity, soil depletion, high level of greenhouse gas emissions). Despite large food production, due to various measures in international trade, hunger and extreme poverty are still present as critical global challenges. Even in areas where population decline is present, inequalities remain, hindering poverty eradication (FAO, 2018a).

As a key part of the global response to food insecurity, the United Nations (UN) Food and Agriculture Organization (FAO) has defined an integral vision of sustainable food and agricultural systems by transitioning to agroecology, which offers a unique approach to meeting the increased food needs of the future. Agroecology provides general principles for sustainable food and agricultural systems that are highly productive, economically viable and environmentally acceptable, and contribute to fairness and social equity. FAO has defined five principles of sustainable agricultural and food systems: 1) improving efficiency in the use of resources; 2) preservation, protection and improvement of natural ecosystems; 3) protection and improvement of living conditions in rural areas, equality and social welfare; 4) strengthening the resilience of people, communities and ecosystems; 5) promoting good management of natural and human systems (FAO, 2018a).

Two international symposiums on agroecology were held in the organization of FAO, the first in 2014 and the second in 2018 (FAO, 2014; 2019). After the first international symposium, a series of regional meetings were held in 2015 and 2016 (Brazil, Thailand, Senegal, China, Bolivia, Hungary), attended by over 1,300 participants from 162 countries. The meetings identified possible actions and public policies that could support better development of agroecology in their regions (FAO, 2015). Regional consultations continued after the second symposium. Consultations for the Caucasus and the Balkans were held in Tirana in 2019. The conclusion from these consultations is that agroecology is an important plan for the region and can play a role in integrating policies for sustainable agriculture, while addressing social and economic issues. In doing so, it was emphasized that continuous awareness raising and promotion of knowledge exchange are of key importance (FAO, 2020).

Agroecology also plays an important role in the implementation of the Decade of Family Farming. Namely, in 2014, the FAO published data on the share of family farms in the overall system of world agriculture and the safe food system (Graeub et al., 2016). About 500 million family farms make up over 98% of all farms in the world. These farms cultivate about 53% of the agricultural land and produce 80% of the total world food production. This was the basis for adopting a resolution declaring the UN Decade of Family Farming, 2019-2028 and proposing to governments a series of measures to support the survival of these farms (FAO and IFAD, 2019). This further confirms that agriculture must be seen as part of the environment and human heritage, and that it is necessary to return to the path of respecting ecological principles and traditional agricultural systems on family farms, i.e. that agriculture should be seen in the interdependence of all living organisms with the environment, without neglecting the socio-economic aspects of this activity.

Agroecology, as part of an integrated approach to landscape management, is also a tool towards the implementation of the Sustainable Development Goals (SDGs), as it can directly contribute to at least 10 of the 17 goals (UN, 2015). Accordingly, during the 31st FAO Regional Conference for Europe, FAO was asked to support and recommend countries to include agro-ecological approaches and diversification in rural and urban policies and planning and thus strengthen agro-ecological work in the context of the Decade of Family Farming (2019–2028) and Initiatives to Increase Agroecology. In this direction, the Fund for Agroecology was established, and states should define incentive policies and incentives for the development of alternative markets for agro-ecological products (FAO, 2018a).

The goal of the UN Agenda for Sustainable Development 2030 (UN, 2015) is to end poverty and hunger (*Ending power and achieving zero hunger*) while simultaneously ensuring inclusive growth and sustainable management of the planet's natural resources. This, especially in the context of climate change, can only be achieved with full commitment to sustainable development. At the same time, this is also a call for a transition towards sustainable food and agricultural systems, which provide safe food and nutrition for all, social and economic equality and the preservation of biodiversity and ecosystem services on which agriculture depends (FAO, 2018a; 2018b). The answer to this question can be seen in agroecology, which offers a unique approach to meeting the needs of future generations. With family farms, including small farmers, indigenous communities, fishermen and farmers in mountainous areas, agroecology seeks to transform agricultural systems, pointing to the root of problems and providing holistic and long-term solutions based on co-creation of knowledge, sharing of innovations including the combination of local, traditional, indigenous and practical knowledge with multidisciplinary science.

The new Global Biodiversity Framework (CBD, 2022), which was adopted at the 15th Conference of the Member States of the Convention on Biodiversity in Montreal in December 2022, among the 17 goals until 2030, defined two significant ones related to sustainable agricultural systems. Goal 7 refers to reducing hazardous chemical pollution, nutrient loss and pesticide risk by at least half. In this sense, countries are invited to support sustainable agricultural systems based on non-pesticide measures. Goal 10 sets the task of sustainable management of areas under agriculture, aquaculture, fisheries and forestry, in particular through the sustainable use of biodiversity and increasing the application of biodiversity-friendly practices, such as sustainable intensification, agroecological and other innovative approaches, which contribute to the resilience and long-term efficiency and productivity of these production systems, and food security, preserving and restoring biodiversity and maintaining nature's contribution to people, including ecosystem functions and services.

Because of all this, the FAO, based on the proposal of the Committee for Agriculture and after the global and regional FAO dialogues, adopted in 2019 ten elements of agroecology developed on a scientific basis, as a guide for the transition towards sustainable agricultural and food systems. Figure 1 and Figure 2 show elements of agroecology: diversity; cooperation, innovation and knowledge sharing; synergies, efficiency, recycling, resilience, human and social values, culture and food traditions, responsible management, circular and solidarity economy and their interaction (FAO, 2018a).

Diversity is key to agroecological transition because agroecological systems are very diverse. Increasing biodiversity contributes to a range of productive, socio-economic, nutritional and ecological benefits (such as ecosystem services including plant pollination; soil management that reduces soil erosion, increases carbon storage, promotes nutrient balance and preserves and enhances biodiversity, optimization of biomass and water collection). In addition, it strengthens both environmental and socio-economic resilience by including everyone and creating new opportunities in the market. All together, the health of the soil, the diversity of crops and animals, reduces the risk of failure due to climate change.

Co-creation, innovation and sharing knowledge. Agroecology does not offer fixed recipes, but actions adapted to the environment and the social, economic and cultural context of each territory. Collaboration and knowledge sharing play a central role in the process of developing and applying agroecological innovations to address challenges in all food systems, including adaptation to climate change. Through the process of creation, agroecology brings together traditional, local knowledge, includes the practical knowledge of producers and traders, and global scientific knowledge. Producers' knowledge of agricultural biodiversity and context-specific management experience, as well as their knowledge of markets and institutions, are key elements of this process. Education - both formal and informal - plays a key role in sharing agroecological innovations resulting from the creation process, creating space for capacity building of farmers, including women's education.

Figure 1. Ten elements of agroecology.

Source: Official images for download:
https://www.fao.org/agroecology/overview/overview10elements/en/

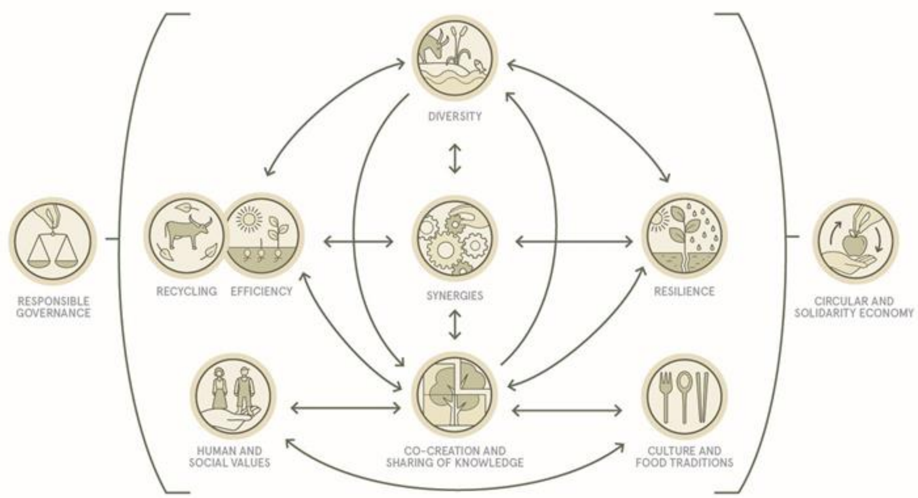

Figure 2. Interaction of ten elements of agroecology.

Source: Official images for download:
https://www.fao.org/agroecology/overview/overview10elements/en/

Synergies. Agroecology carefully encourages the creation of diverse and synergistic systems, including a combination of annual, perennial and cover crops, livestock, aquatic animals and trees. Special attention is paid to the careful use of soil, water and other components of agricultural properties and landscapes in order to increase resilience in the context of an increasingly changing climate. In order to promote synergy in the wider food system and best manage trade-offs, agroecology emphasizes the importance of partnership, cooperation and responsible management, involving different actors at multiple scales.

Efficiency. Innovative agroecological transitions make the transition from systems based on high inputs to production systems based on knowledge with the aim of further increasing productivity while using fewer external resources. Increased efficiency of resource use is a new feature of agroecological systems. Agroecological systems improve the use of natural resources, especially those that are abundant and free, such as solar radiation, atmospheric carbon and nitrogen. By enhancing biological processes and recycling biomass, nutrients and water, producers are able to use available resources more efficiently, reducing costs and negative environmental impacts and contributing to an increase in their net income over time.

Recycling. Mimicking natural ecosystems, agroecological practices support biological processes that drive the recycling of nutrients, biomass and water within production systems, thereby increasing resource efficiency. Recycling can take place on farms and within the landscape, by diversifying and building synergies between different components and activities. Recycling brings multiple benefits by closing the nutrient cycle and reducing waste, and it also enables cost reductions in input raw materials, which reduces their vulnerability to climate shocks and price volatility. Recycling of organic materials and by-products offers great potential for agro-ecological innovation.

Resilience. Various agroecological systems are more resistant, ie. they have a greater capacity to recover from disturbances, including extreme weather events such as drought, flooding or hurricanes, and to resist attacks by harmful organisms, maintaining functional balance. Agroecological practices act as biologically complex agricultural systems and thus foster a diverse community of interacting organisms to enable the ecosystem to self-regulate in the face of pests and diseases. Namely, diverse agricultural landscapes have a greater potential to contribute to pest and disease control through ecosystem services (e.g. natural enemies for biological control). Agroecological approaches can also improve the socio-economic resilience of an area, because through diversification and integration, producers can better manage risks and thus reduce vulnerability if one crop or other commodity fails, and by reducing dependence on external inputs, producers' vulnerability to economic risks is also reduced.

Human and social values. Protecting and improving lifestyles, incomes and equity are important for sustainable food and agricultural systems. Agroecology emphasizes human and social values and the inclusion of everything that contributes to the improved dimension of achieving the goals of sustainable development. By building autonomy and adaptive capacity to manage their agroecosystems, agroecological approaches empower people and communities. As a bottom-up approach, which is the basic paradigm of sustainable rural development, agroecology enables people to become their own drivers of change.

Culture and food traditions. By supporting a healthy, diverse and culturally appropriate diet, agroecology contributes to food security while maintaining healthy ecosystems. Agriculture and food are the basic components of human heritage. Culture and food traditions play an important role in society and in shaping human behavior. The genetic diversity of different crops, breeds and species is important for providing a diverse diet. Cultural identity and sense of place are often closely tied to landscapes and food systems. Humans and ecosystems have evolved together, which is why cultural practices and indigenous and traditional knowledge offer a wealth of experience that can inspire innovative solutions.

Responsible governance. Sustainable agriculture and nutrition require responsible and efficient governance mechanisms at different scales - local, national, regional and global. Agroecology calls for responsible and efficient management that provides support for the transition to sustainable food and agricultural systems. Transparent, accountable and inclusive governance mechanisms are needed to create an environment that allows producers to transform their systems while considering agroecological concepts and practices. Land and natural resource management is an excellent example. Most of the world's poor and vulnerable populations rely heavily on terrestrial and aquatic biodiversity and ecosystem services for their entire lifespan, but lack secure access to these resources.

Circular and solidarity economy. Circular and solidarity economies that reconnect producers and consumers provide innovative solutions for living within our planetary boundaries, while providing the social basis for inclusive and sustainable development. Agroecological approaches help promote fair solutions based on local needs, resources and capacities, creating fairer and more sustainable markets. Strengthening short food chains can increase the income of food producers while maintaining a fair price for consumers. These include new innovative markets, along with the more traditional markets where most smallholders sell their products. Social and institutional innovations play a key role in encouraging production and consumption based on agroecological approaches that appreciate the hidden value of biodiversity and ecosystem services.

From all of the above mentioned, it is clear that agroecological systems are very diverse. From a biological perspective, agroecological systems optimize species diversity and genetic resources in different ways. For example, agro-forestry systems organize crops, shrubs and trees of different heights and shapes at different levels or layers, which increase vertical diversity. Intercrops combine complementary species and thus increase spatial diversity. Crop rotation, which often includes legumes, increases temporal diversity. Crop and livestock systems rely on a diversity of local breeds adapted to specific environments (IPES-Food, 2016). A diversity of crops and animals also reduces the risk of failure to cope with climate change. Mixed grazing of different ruminant species reduces the health risks of parasitism, while different local species or breeds have greater abilities to survive, produce and maintain reproduction levels in disturbed conditions. On the other hand, various sources of income from differentiated and new markets, including various food products and agritourism, help stabilize household incomes. Eating a variety of grains, legumes, fruits, vegetables, and animal products improves nutrition. The genetic diversity of different cultivars, breeds and species is important because it provides macronutrients, micronutrients and other bioactive compounds in the human diet. For example, in Micronesia, the reintroduction of underutilized traditional orange-fleshed banana varieties with 50 times more beta-carotene than the widely available commercial white-fleshed banana has proven to be a good instrument in improving health and nutrition (Englberger et al., 2006). On a global level, three cereals provide close to 50 energy needs of humans and animals. At the same time, the genetic diversity of crops, livestock, aquatic animals and trees continues to be rapidly lost. Agroecology can help reverse these trends through the management and conservation of agro-biodiversity and by responding to the increasing demand for a variety of eco-friendly products. One such example is "fish-friendly rice" produced from irrigated, rain-fed and deep-water rice ecosystems, a system that values the diversity of aquatic species and their importance to rural life (IPES-Food, 2016).

Agroecology in Europe

In 2019, IPES-Food (International Panel of experts on sustainable food systems) prepared a document that is a call for EU policy reform in order to build sustainable food systems in Europe (IPES-Food, 2019), explaining why a change in policy is necessary. The current policy has a major impact on the environment, as 970 million tons of soil is lost in Europe every year on more than 11% of the EU territory affected by moderate to severe erosion. Pesticides and nitrogen fertilizers have unprecedented negative effects on plant and insect life. There is a huge loss of biodiversity, which threatens a range of nature's services including the pollination of many food crops (future yields worth around 3% of global GDP are at risk each year).

In October 2018, Pesticide Action Network Europe (PAN) prepared a proposal for a new model of the Common Agricultural Policy (CAP) after 2020, which proposes fundamental improvements to the CAP by introducing a much-needed agro-ecological transition. It is proposed that each member state offers farmers financial support for the application of non-chemical alternatives to pesticides (agronomic, mechanical, physical, biological), as part of an overall strategy that moves towards smarter agroecological production systems, from integrated pest management (IPM) to organic farming with final the goal of "zero pesticides". The consumption of pesticides in the EU 28 amounted to 380 million kg of active substance in 2016 (PAN, 2018). Unfortunately, few of these recommendations found a place in the CAP 2023-2027.

Globally, agricultural and food systems contribute up to 30% of greenhouse gas emissions. As much as 31% of the land needed to meet food needs in the EU is located outside Europe. The EU imports about 22 million tons of soy-based feed every year. It is estimated that EU imports represent almost a quarter of world trade in soy, beef, leather and palm oil. Less than half of EU fish and seafood consumption is met by EU production, meaning that Europe's impact on global marine resources is also huge. In other words, the EU is leaving an ever deeper ecological footprint of its food systems and habits. This is further exacerbated by the fact that around 20% of food produced in the EU is lost or wasted (that's €143 billion a year in terms of wasted resources and environmental impact (IPES-Food, 2019).

Agriculture is responsible for around 90% of ammonia emissions in the EU, which is a major contributor to air pollution. The concentration of pesticides in groundwater exceeds quality standards in several member states. Over 50% of the European population is overweight and more than 20% are obese. Unhealthy diet is the leading risk factor for disease and mortality in Europe, and it hits the poor population hardest. An unhealthy diet is responsible for 49% of the burden of cardiovascular disease - the leading cause of death in the EU. Chronic diseases - often linked to nutrition - account for 70% - 80% of healthcare costs in the EU. Moreover, today every fourth European is exposed to the risk of poverty or social exclusion (in 2016, about 43 million people, or 9.1% of the EU population, could not afford a quality meal every other day) (IPES-Food, 2019).

The socio-economic impacts of the current systems are also great. About 70% of the global agrochemical industry is now in the hands of just three companies, and up to 90% of the world's grain trade is controlled by four multinational companies. In 2011, the five largest food retailers in thirteen EU member states had a combined market share of over 60%. From 2003 to 2013, more than 1 in 4 farms disappeared from the European landscape. Around 3% of farms now manage 52% of agricultural land in the EU, and only 20% of farms receive 80% of CAP payments. Under such conditions, more than 100,000 hectares of agricultural land in the EU are lost to urban and/or industrial development every year. Rural landscapes could further disappear as the agricultural population ages (in 2013, almost half of agricultural holdings were over 55, and a quarter over 65). There is an erosion of traditional food cultures. The urban city lifestyle has changed the habits of food preparation and consumption and caused a loss of consumer connection with the way of preparing food and the seasonality of fruits and vegetables. Because of all of the above, a fundamental policy change is needed to make food systems sustainable, stop the loss of biodiversity, suppress obesity and make agriculture sustainable for future generations (IPES-Food, 2019).

Migliorini et al. (2018) analyzed the agroecology of three Mediterranean countries: Italy, Greece and Spain. They stated that there are several similarities but also differences. Agroecology arose mainly as a link between traditional agricultural knowledge and the organic farming movement, emphasizing social and political aspects. In Italy, the genesis of agroecology is linked to academia, but recently it has been strongly linked to civil society, non-governmental organizations and consumers. In Greece, the organic agriculture sector appears as the main actor of an integrated approach towards recognizing the necessity of adopting a holistic, agro-ecological concept through the inclusion of practice. In Spain, the acceptance of agroecology is related to Andalusia, also organic farming. Agroecology studies and training and research, although progressing recently in Mediterranean Europe, still face many challenges. Stassart et al., (2018) analyzed the Belgian approach to agroecology and concluded that the concept of agroecology still has potential in Belgium today, but no one can predict the course of such, mostly non-institutional dynamics. The analysis of the development of agroecology in the countries of Eastern Europe shows that it is connected with the development of organic agriculture. Between the 1950s and the 1990s, there were significant differences between individual countries in Eastern Europe. Collectivization, specialization, and intensification of agriculture advanced the most in Bulgaria, Czechoslovakia, and Hungary, which is why the impact of agriculture on the environment is more pronounced than in other countries of the former Eastern bloc. Therefore, agroecology mainly deals with those impacts. In these countries, agroecology is seen more as a scientific field with the task of establishing a balance between productive and non-productive functions of agroecosystems (Moudrý et al., 2018).

Agroecology in B&H

Agroecology is weakly present in BiH and is generally not recognized as a concept of a sustainable food system. However, multiple sectors deal with different issues that can be considered as the basis for the future development of agroecology at different levels, from agricultural holdings to the development of legislation and strategies. These issues include organic agriculture, environmental protection, direct links between producers and consumers, circular economy, fair economic practices and social inclusion (Hetman and Kalaba, 2023).

Earlier research (Marković, 2005) on the impact of new socio-economic relations on land use and biodiversity on and around farms in BIH on the example of two municipalities (Banja Luka and Derventa) showed that migration due to war significantly affects them, both positively and negatively. The same author in another paper (Marković, 2013) provides an overview of how crop diversification can improve the biological control of harmful organisms. Rokvić (2011) made a comparison of the general indicators of agricultural development in the EU and the countries of the Western Balkans, through the analysis of the main goals and support measures identified in the common agricultural policy of the EU and the IPARD regulation, as the two main pillars of support to countries for agricultural policy reform.

Research on the possibility of introducing agroecological measures into the agricultural policy of the Republic of Srpska (Mićić, 2019; Mićić et al., 2022) showed that a significant number of measures corresponding to agroecological measures in the EU were determined by strategic documents. Although all laws in the field of agriculture, forestry and water management include in their goals sustainable development and preservation of the environment, the regulatory framework provides incentives for only a small number of measures planned in the strategic framework. At the same time, preservation of biodiversity, protection and sustainable use of genetic resources, preservation of natural landscapes and agricultural systems of high natural value are not recognized as essential values of cultural and natural heritage. The interviewed farmers apply a certain number of agroecological measures, although they do not receive incentives for them, and they are generally not familiar with the concept of agroecology or the schemes of agroecological measures, except for the concept of organic agriculture and partially the concept of integral agriculture. However, most of the respondents would be ready to accept the agro-ecological concept on a wider, territorial level with appropriate counseling and training.

The analysis of the regulatory framework showed that although many agro-ecological measures are foreseen in the Strategic Plan for the Development of Agriculture and Rural Affairs of the Republic of Srpska (2016-2020), there are no such measures in the relevant laws and by-laws, and therefore there is no support for those measures in the rulebook on conditions and the method of achieving financial incentives for the development of agriculture and villages (Mićić, 2019). The new Strategic Plan for the Development of Agriculture and Rural Areas of the RS, 2021-2027, also includes some goals, such as revitalization of rural areas and nature protection and sustainable use of natural resources, but again the concept of agroecology is not recognized (Government of the Republic of Srpska, 2021).

When it comes to education in BIH in the field of agroecology, it can be stated that there is no generally accepted definition of agroecology. This term is more commonly used to separate systems with agricultural production versus natural systems, regardless of the type of production system. The literature most often mentions agroecological conditions for growing certain crops or agroecological requirements of certain species. Faculties in BIH have included the principles of sustainable development and sustainable agriculture in their curricula in the past period, and some faculties have also introduced education with a specific profile for agroecology and rural development (Biotechnical Faculty in Bihać), i.e. environmental protection in agriculture (Agro-Mediterranean Faculty in Mostar). At the Faculty of Agriculture in Banja Luka, there are several courses that deal with certain aspects of sustainable agricultural systems, but the modern concept of agroecology has not been adopted within the Agroecology course. International projects and research teams that could define the modern concept of the introduction and development of agroecology in domestic policies are active at this faculty, but due to the lack of understanding of the importance of the concept of agroecology and the importance of the transformation of agriculture towards sustainable agricultural systems at the level institution of government (Mićić et al., 2023) as well as the weak integration of science and the agricultural practices (Mićić et al., 2018), the current situation is not encouraging.

The results of the TAPE survey conducted in selected territories in BIH confirm previous findings (Mićić et al., 2023). FAO has developed an agroecology performance assessment tool - TAPE (FAO, 2019) to support local development towards sustainability and to identify the needs of farmers in the transition process. The tool has 4 steps. Step 0 describes production systems, farm type, agro-ecological zones, existing policy and environment. In step 1, the farm survey describes the current situation based on the Characterization of Agroecological Transition (CAET). Step 2 provides measure progress and impact quantification and analysis of time and cost constraints. Based on a participatory approach at the community level, step 3 reviews the results of CAET and analyzes their contribution to the Sustainable Development Goals (SDGs). TAPE was applied to small family farms on the territory of two territories in BiH, Trebinje and Ljubinje, during 2021 (Mićić et al., 2023). The interviewed farms are divided into two groups: market-oriented production with 1-2 main products and ecological mixed production mainly for own consumption based on domestic and autochthonous species including beekeeping. The analysis showed that the main characteristics of the selected area are a very strong tradition and culture of local cuisine, pronounced depopulation and aging of households, spatial disconnection and weak infrastructure (internet, somewhere GSM signal, roads, schools, kindergartens, health centers, etc.). The region still has an active rural population with production organized on family farms. The support of the local community has been established through the agricultural fund to support farmers, the organization of local sales of products and advisory services, but this support is still insufficient and not long-term. Agricultural production is mostly traditional and small. Although the migration of young people to the city and abroad is a big problem, a significant part of the rural youth population wants to stay and live from agriculture if clear and long-term support measures were provided.

FAO also conducted an analysis of agroecology in the regions of Europe and Central Asia (FAO, 2020). This analysis shows that agroecology is not integrated into policies and in most of these countries agricultural production and environmental protection are seen as separate domains. Even the word agroecology is underused and poorly understood not only by most farming communities, but also by those in advisory services and other relevant government bodies. This analysis shows that smallholder farmers in BIH use low chemical inputs, rely on manure as fertilizer, and exchange local food products between families and other community members. The integration of agroecology in the country is in the initial stages: there are some planned measures in the latest rural development strategies. The public advisory service does not promote agroecology, but covers some aspects of integrated pest management (IPM) and organic production. Despite this, communities in BIH continue to maintain some cultural landscapes that combine traditional agricultural methods, high agrobiodiversity and unique agroecosystems. In a broader sense, small farmers are not recognized in national sanitary and phytosanitary measures, which has implications for their access to better markets and the way they produce in terms of the environment. It is also noted that agroecology is recognized as a science in the curriculum of the University of Banja Luka, and that there is a new master's degree on the subject of Conservation and sustainable use of genetic resources. The EU Horizon 2020 project called EcoStack in which this university is a partner (EcoStack, 2019) aims to develop and support ecologically, economically and socially sustainable crop production through stacking and protection of functional biodiversity. Although there seems to be fertile ground for agroecological farming practices and local movements in the country, there is no formal system for promoting and protecting the traditional and local knowledge (Barudanović et al., 2023).

With the support of FAO and Schola Campesina from Italy, the School of Agroecology project (Schola Campesina, 2023) was developed, i.e. a knowledge sharing project to strengthen the agroecological movement in the Europe and Central Asia (ECA) region, including BIH. In the context of the abandonment of agricultural activities and the rural exodus in all ECA countries, the project aims to strengthen the organizations and networks of local food producers by supporting the actions of local organizations in rural areas and especially their knowledge-related activities. Informal agroecological schools are crucial in supporting food producers in their agricultural activities (economic sustainability, access to markets, food processing, local policies, organizational model, political advocacy, among others) and in building alliances for improved and coordinated policy support for agroecology. The project established the digital platform Bilim as a tool to strengthen organizations at the national and international level. These organizations held the first Agroecology Forum in Eastern Europe and Central Asia in July 2023 in Bursa, Nilufer District, Turkey. The event brought together 22 organizations from 18 different countries, from four main sub-regions: 1) Central and Eastern Europe, 2) Western Balkans, 3) South Caucasus and Western Asia and 4) Central Asia. Participant of the project and the Bilim forum and platform from BiH is the Alica Foundation from Banja Luka. The agroecology school created in this way will enable a better exchange of knowledge and the capitalization of knowledge that is not available to the wider network today.

Conclusions

- Agroecology involves the integration of research, education, social action and change aimed at the sustainability of all parts of the food system (ecological, economic and social aspects) and is a key part of the global response to food instability as it offers a unique approach to meeting the increased food needs of the future.
- Agroecology is weakly present in BiH and is generally not recognized as a concept of a sustainable food system.
- Although many agro-ecological measures are foreseen in the strategic framework, there are no such measures in the relevant laws and by-laws, and therefore there is no support for those measures.
- Agricultural producers in BIH are generally not familiar with the concept of agroecology or the schemes of agroecological measures, except with the concept of organic agriculture and partly with the concept of integrated agriculture.
- Some agricultural producers apply certain agroecological measures following traditional knowledge and not because of modern knowledge and do not receive incentives for them.
- Most agricultural producers, with appropriate counseling and training, would be ready to accept the agroecology concept on a wider territorial level, which can be successfully implemented through the already established agroecology school program implemented with Alica Foundation through the international forum for agroecology and the Bilim digital platform.

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ROLE OF DIGITALIZATION IN SUSTAINABLE AGRICULTURE: BENEFITS, CHALLENGES AND USE CASES

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Abstract

Digitalization has the potential to address the challenges of productivity, sustainability, and resilience in agriculture. The adoption and impact of digital agriculture in OECD countries have been well documented for row crop farms, but there is limited information on the use of digital technologies in livestock and speciality crop farming. Barriers to adoption include cost, relevance, user-friendliness, operator skill requirements, mistrust of algorithms, and technological risks. National governments play a crucial role in overcoming these barriers by providing information on costs and benefits, investing in human capital, incentivizing innovation, facilitating data sharing, and promoting competitive markets.

Key words: Agriculture, technology, digitalization, crops, farmers.

Introduction

The agricultural sector faces numerous challenges at both global and local levels. The increasing demand for food and other ecosystem services places pressure on agricultural production potential. Factors such as climate change and soil degradation further exacerbate these pressures. This leads to difficulties in delivering both private and public goods, increasing costs. Additionally, agriculture contends with various shocks and challenges, including extreme weather events, market fluctuations, pandemics, and conflicts, which reduce the resilience of the sector. Furthermore, the environmental impacts of the agri-food system, such as resource overuse, pollution, greenhouse gas emissions, and biodiversity loss, need to be addressed (Fielke et al., 2020).

Recent policy goals, such as the Kunming-Montreal Global Biodiversity Framework and the Farm to Fork strategy of the European Union, aim to meet ambitious environmental targets in a short time frame (Candel et al., 2023). Social sustainability and animal welfare issues also require urgent attention. To overcome these challenges, the agricultural sector must deliver more while reducing its environmental footprint with fewer resources. However, this goal can lead to conflicts between food production, profitability, and environmental protection. Resolving these conflicts is crucial for a sustainable and resilient agricultural sector.

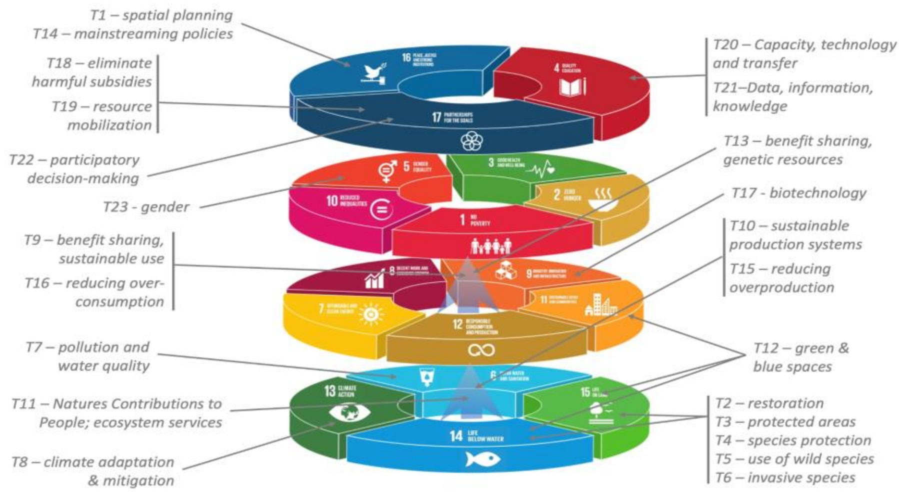

Figure 1. The Kunming-Montreal Global Biodiversity Framework, Biodiv Sci, 2023

Digital technology is increasingly being used in agriculture, even in underdeveloped nations. In order to help farming communities and agricultural systems recover from stressors and absorb shocks of many origins to which farmers and their environment are exposed, digitization attempts to promote networking and connections along the agricultural value chain. However, there is worry that, particularly in Sub-Saharan Africa, digital technologies have not significantly improved the agriculture sector (Deichmann et al., 2016; The Technical Centre for Agricultural and Rural Cooperation [CTA], 2019). The literature has extensively covered the employment of modern technologies in the fields of farming and food safety.

Increasing productivity, environmental sustainability and competitiveness, digitalisation has the potential to revolutionise the European agricultural sector. The latest technological innovations, such as artificial intelligence (AI), robotics, Internet of Things (IoT) and 5G, can decisively support farmers and agribusinesses. Through digitalisation, the value chain might become more efficient, fostering better cooperation and communication between growers, processors, distributors, and customers (Jaiganesh, 2017). While this takes place, innovative SMEs may grow and prosper, advancing the industry with cutting-edge ideas and fresh perspectives.

Looking at the data provided by Eurostat, an increase in the use of technology can be observed, which may entice farmers to use the Internet for their farm activities.

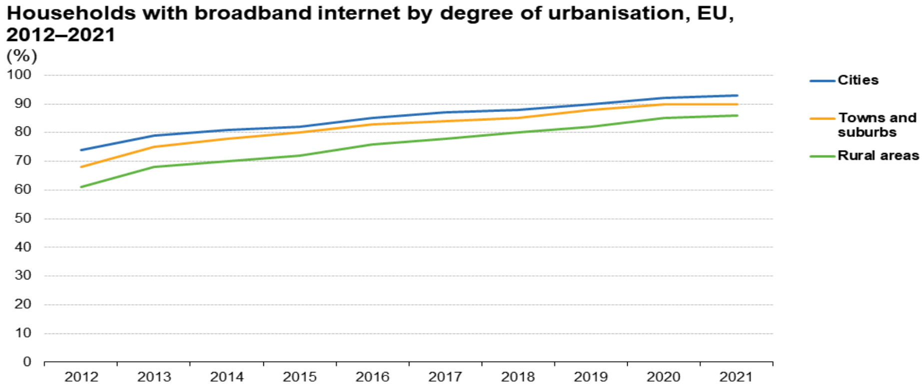

Figure 2. Households with broadband internet by degree of urbanisation, Eurostat, 2022

The number of homes in the EU with broadband connections has rapidly increased in recent years to a level where the market is almost saturated. 9 out of 10 homes in the EU had access to broadband internet by 2021; this percentage was somewhat higher in urban regions (93%) and significantly lower in rural areas (86%), however, this difference has narrowed over the past ten years. To round out the picture, in the suburbs and towns in both 2020 and 2021, 90% of homes in the EU have access to broadband internet.

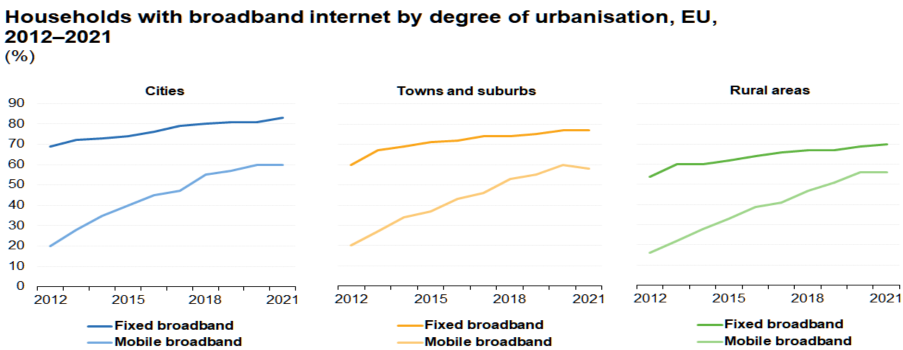

Figure 3. Households connected to the internet by type of connection and degree of urbanisation, Eurostat, 2022

During 2012, fixed-line broadband was the most widely used method of accessing the Internet throughout the EU, but mobile broadband was still in its infancy. A rising number of EU homes are now using mobile broadband to access the internet thanks to the development of fourth and fifth-generation (4G and 5G) broadband cellular networks. Figure 2 demonstrates how, between 2012 and 2020, the use of Cellular broadband in the EU increased quickly from a relatively low base level; however, in 2021, the proportion of household members connected to mobile broadband began to decline among households in suburbs and cities and to stagnate in both urban and rural areas.

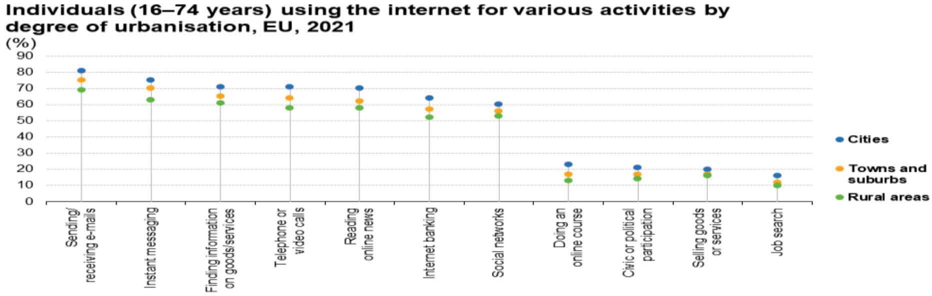

Figure 4. Individuals (16–74 years) using the Internet for various activities by degree of urbanisation, Eurostat, 2021

It may not come as a surprise to learn that a higher percentage of people who live in cities (compared to those who live in suburbs and towns or in rural areas) use a variety of different gadgets to access the internet. This higher percentage also applies to the number of people who use the internet for different reasons.

Figure 5 reveals the percentage of persons (aged 16 to 74) who engage in three distinct online activities: email sending and receiving, instant messaging, and online banking. Although there were few exceptions, those who lived in cities tended to use the internet more frequently for all three of these purposes.

In terms of sending and receiving emails, people who live in cities and suburbs were found to have the highest percentages in Belgium, Malta, and the Netherlands, while those who reside in rural regions were found to have the highest percentage. In Greece, Cyprus, and the Netherlands, people who live in cities as well as suburbs accounted for the largest percentages of instant messaging users. In both Belgium and Malta, residents in cities and the suburbs accounted for the largest percentages of internet banking users.

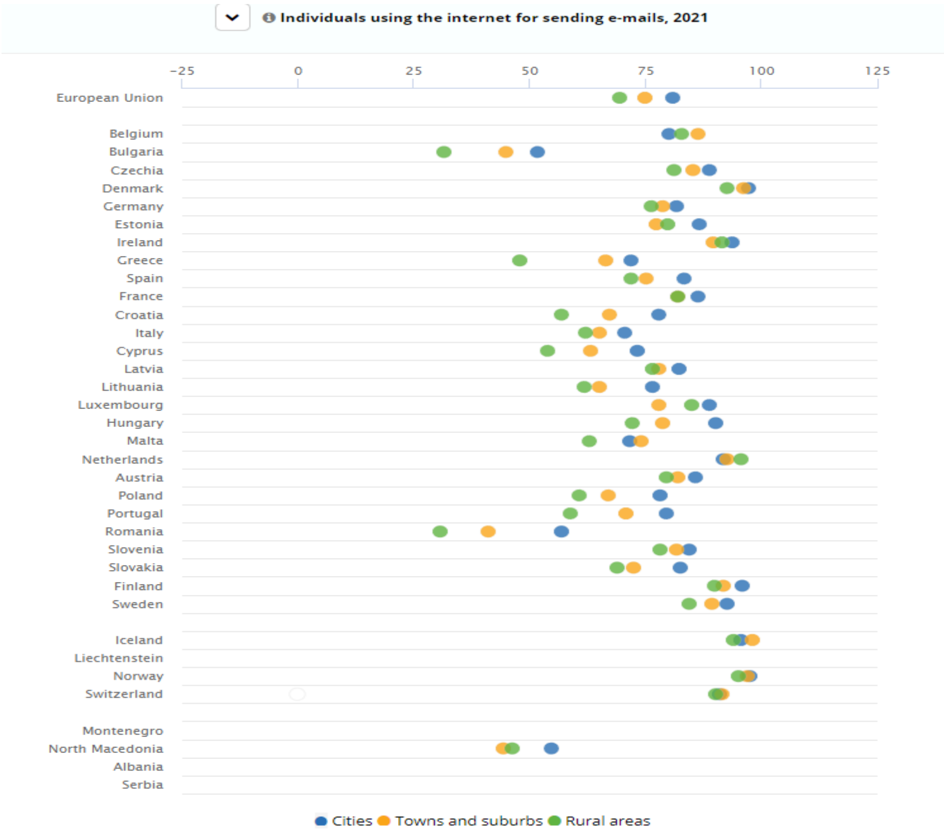

Figure 5. Individuals using the internet for sending e-mails, Eurostat, 2021

Despite its numerous advantages, digitalization may also widen the gap between those who have access to advanced technology and those who do not. This gap might exist between connected and unconnected farms, as well as between small and large agricultural enterprises. Governments, business titans, and technology suppliers may assist in ensuring that digitalization is equitable and available to everyone by highlighting its benefits and offering farmers training, resources, and subsidies to use new technologies (Zhong, 2023). This presents an opportunity for the European agriculture industry to harness the advantages of the digital era, enhancing the sustainability and economic stability of farming endeavors, while simultaneously tackling urgent concerns such as food security and environmental deterioration.

The agricultural landscape has been transformed by the Internet of Things (IoT), ushering in a new era for farmers by delivering up-to-the-minute insights about their machinery and the surrounding environment. This wealth of data empowers farmers to enhance every facet of their operations, spanning agricultural production and livestock welfare. Through the integration of precise geographical information and real-time IoT data, farmers are embracing precision farming, leading to heightened yields, diminished waste, and the promotion of ethically sound practices. Farmers can remotely monitor both their crops and their livestock thanks to IoT technology, which reduces labour expenses and assures the well-being of their animals (Kassim, 2020). In order to facilitate the exchange of data and ensure seamless collaboration among various applications and participants within the European agricultural industry, it is essential to establish a robust network of data-sharing tools and ecosystems, creating a unified agricultural data environment.

Benefits

Digitalization has the potential to tackle the challenges of productivity, sustainability, and resilience in agriculture. The search results have highlighted several key findings:

Benefits of digitalization in agriculture (Bacco et al., 2019):

- Digital technologies can enhance on-farm productivity, improve resource usage efficiency, and support climate resilience.
- It is seen as a promising tool to sustainably increase food production for a growing global population.
- Digitization aims to enhance networking and connectivity throughout the agricultural value chain, enabling farming communities and systems to recover from stress and adapt to different shocks.

Barriers to adoption:

- Common barriers include upfront costs, limited relevance and use cases, user-friendliness concerns, skill requirements, mistrust of algorithms, and technological risks (McFadden et al., 2022).
- Limited evidence exists regarding the adoption and impact of digital agriculture in livestock and speciality crop sectors (McFadden et al., 2022).

Role of national governments:

- National governments have a crucial role in addressing barriers to adoption. This includes providing better information on the costs and benefits of technologies, investing in human capital, creating incentives for innovation, acting as knowledge brokers to facilitate data sharing, and promoting competitive markets (McFadden et al., 2022).

At the same time, researchers, policymakers, and other key players are becoming more aware of the potential advantages of agricultural digitalization to promote changes towards sustainable agriculture. In fact, technological advancements like the use of in situ and remote sensing technology for precision agricultural applications may significantly enhance the efficiency of resource usage (for example, for the application of fertiliser, chemicals, or water) and lower greenhouse gas emissions (Ferrari et al., 2022). However, there is still room for improvement when it comes to the systems-oriented integration of sizable datasets accessible for recording related activities at the field and landscape scales, as well as the integrative analysis and conversion of such data into useful crop management alternatives.

In summary, while digitalization offers significant potential benefits to agriculture, there are obstacles to its adoption. National governments can play a vital role in facilitating the widespread use of digital technologies in this sector (Ferrari et al., 2022).

Challenges

The adoption of digital technologies in agriculture in developing countries encounters various challenges, including:

- Limited access to digital technologies: In rural areas of developing countries, inadequate infrastructure like internet connectivity and electricity supply hampers access to digital technologies (Rodino et al., 2023).
- High upfront costs: The initial investment required for implementing digital technologies can be prohibitively expensive, particularly for smallholder farmers with limited financial resources (Ozdogan, 2017).
- Limited suitability and use cases: Digital technologies may not be relevant or applicable to all crops and farming systems, restricting their adoption in countries with diverse agricultural practices (Shamshiri et al., 2018).
- Complexity and skill requirements: Operating digital technologies often demands specialised skills that may be lacking in developing countries. Additionally, user interfaces may be unfriendly, further hindering adoption efforts (Dörr & Nachtmann, 2022).
- Mistrust and technological risks: Concerns around algorithm reliability, data privacy, and security may result in hesitancy among farmers when it comes to embracing digital technologies (Abioye, 2022).
- Insufficient research and development: Many digital innovations are designed for large-scale commercial farming in high-income countries, limiting their suitability for small-scale producers in developing countries. More research and development efforts targeting the specific needs of these farmers are required (Rodino et al., 2023).

Agriculture is becoming more digitised, and there are numerous steps that may be taken to speed up the process, such as Investment in Research and Development: For the continuous expansion and development of digital technologies in agriculture, investment in research and development is essential. This involves spending money on developing new apps and solutions for the industry as well as new technologies like blockchain and artificial intelligence. Furthermore, education and training play a crucial role in digitalizing the agricultural sector. These two factors are crucial for the widespread adoption of technological advances in agriculture. This comprises instruction for farmers and food producers who must be proficient in the use of digital technologies, as well as instruction for food corporations and organisations that must be capable of implementing and managing digital solutions.

Moreover, infrastructure development is essential for agriculture's digitalization (Rodino et al., 2023). Investments in data storage and processing technologies, as well as internet access, particularly in remote regions, are included in this. Additionally, public-private collaborations should be more prevalent since they are essential to the digitalization of agriculture. To assist in the creation and use of digital technologies and solutions, these collaborations may bring together organisations from the public sector, the private sector, and academic institutions (Paraforos & Griepentrog, 2021). The adoption of digital technologies across the board in the agriculture sector, including farming, food production, and supply chain management, is referred to as the "digital change" of agriculture. This transformation aims to lessen waste and its negative effects on the environment while increasing efficiency, production, and profitability (Rodino et al., 2023).

Precision agriculture, which employs data and technology to optimise crop yields and the use of resources on a field-by-field basis, is a significant component of the digital revolution in agriculture. This can involve the use of tools like GPS mapping, soil sensors, and drones to gather information on the health of the crops, the state of the soil, and weather patterns. After gathering the information, it is examined to help with decisions about irrigation, fertiliser use, planting methods, and seed selection. The management of cattle is yet another area where technological innovation is making a difference. Farmers may obtain real-time information on the condition and behaviour of their animals through the use of sensors, wearables, and other monitoring systems. Utilising this knowledge can help manage the herd better, stop disease outbreaks, and lessen animal discomfort (Paraforos & Griepentrog, 2021).

The supply chain is being impacted by the digital revolution in agriculture, in addition to farm applications. One example of how technological innovation is being utilised to increase efficiency and transparency in the food supply chain is the use of blockchain technology. Blockchain can assist in tracing the origin of food goods, tracking their travel through the supply chain, and ensuring that food safety requirements are being observed by providing a secure, decentralised record of transactions.

National governments can play a vital role in addressing these challenges. They can invest in improving infrastructure, provide financial incentives to facilitate adoption, support research and development efforts, and promote knowledge-sharing and capacity-building initiatives. By overcoming these hurdles, the widespread adoption of digital technologies in agriculture can be promoted, leading to improved productivity and sustainable development in developing countries (Paraforos & Griepentrog, 2021).

Use Cases

In prosperous countries, there are many examples of the effective application of digital technology in agriculture. Here are a few instances: American digital agriculture technology: In the US, digital farming technology is being used to increase produce quality and volume while more effectively utilising resources like water and fertiliser. This has made it possible for precise monitoring, efficient operations, and knowledgeable management (Verdouw et al., 2021).

In order to increase agricultural operations' productivity and lessen their negative effects on the environment, Europe has introduced smart farming. Farmers may gain better insights in order to make more educated choices, increase production, and save waste thanks to digital technologies including data science, digital means of communication, automation, and sensors in the field. Australia's use of digital agriculture is intended to increase the productivity and sustainability of farming activities. To achieve this, it has been necessary to use digital technology to strengthen value-chain operations and create more durable food systems. Canada's implementation of precision agriculture aims to increase agricultural output and quality while minimising environmental effects. With the use of digital technology, farmers can properly monitor the health of their crops and the soil, which may help streamline processes and boost yield quality and quantity (Pylianidis et al., 2021).These case studies show how digital technologies have the potential to increase the productivity, sustainability, and adaptability of farming operations in industrialised nations.

Conclusions

To conclude, agriculture is becoming more digitised on a continuous basis. A number of variables, including market forces, government regulations, technological developments, and financial availability, impact this process. Despite the difficulties and barriers, farmers, food producers, and consumers stand to gain significantly from the sector's digitalization, including higher production and efficiency, better food safety and quality, and more transparency and dependability in the food chain. By making investments in public-private partnerships, infrastructure development, education and training, research and development, and education, we can continue to accelerate the digitization process and fully use digital technology in agriculture. In many areas of the economic chain, from agricultural production to the end user, digital technologies are accelerating transformation. The use of these technologies will increase productivity, generate new employment opportunities, create new revenue streams, and conserve resources. More research is needed to determine how digital technology may affect agri-food markets. For problems to be solved, all parties involved must work together more closely. Additionally, agreement is required on the best way to develop a regulatory framework that maximises the advantages of digital technologies for agriculture and reduces the potential risks connected with them.

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CHARACTERISTICS OF PRODUCTION, TRADE AND CONSUMPTION OF PLUMS IN SERBIA[1]

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Abstract

The aim of the paper is to determine the importance of production, turnover and consumption of plums in Serbia in the period 2013-2022. The main data sources are the Statistical Office of the Republic of Serbia (SORS) and the International Trade Centre (Trade Map). Also, appropriate scientific and professional literature was used with contents that correspond to the topic of the paper. By applying a quantitative research method, the basic characteristics of the production, turnover and consumption of plums in Serbia were analyzed, namely: area, production, yield, statistical indicators (Import dependency ratio-IDR; Self-sufficiency ratio-SSR; Consumption per capita-Cpc) and the export of plums, both in terms of quantity and value. According to the obtained results, it was observed that the features of plums production are constantly decreasing, that Serbia has a low value of dependence on imports, a high rate of self-sufficiency in fresh plums because it exports significant quantities, high consumption per capita and that about 50% of the total value of exports is placed in the top five countries of the European Union (EU).

Key words: Dependence on imports, degree of self-sufficiency, fruit growing, plums, export.

Introduction

Fruit is an important product for proper nutrition of the population (Ostojić et al., 2019). Authors' Kljajić et al., (2015) point out numerous advantages of fruit production comparing the other agricultural fields, primarily because it employs more labor, provides greater opportunities for employment and attracts the attention of various companies. Kljajić et al., (2013) state fruit growing as the most productive branch of agriculture because a significant number of fruit species can be grown on weaker soils in terms of physical, chemical and other properties, as well as on soils with a greater slope. Fruit production achieves up to 10 times higher production value per hectare than wheat and corn production, which is another economic advantage. In fruit growing, the principle of growing

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in a protected area is increasingly being applied, which depends on the fruit culture being grown (Marina, Grujić Vučkovski, 2022). The purposes for this type of production are multiple, namely: achieving stable and high yields, easier production management, control of microclimate parameters, etc.

Plums are the most important stone (Birwal et al., 2016) and table fruit (Rozman et al., 2017) which is extensively cultivated worldwide (Maglakelidze et al., 2017). According to FAO data for 2021 year (FAO STAT, Rankings countries by commodity), Serbia is among the first of five countries in the world according to the quantity of plums produced (412,778 t) and ranks fourth place, while the leaders are: China with 6,615,469.1 t, Romania with 807,170 t and Chile with 426,776.28 t. Looking at the production of all stone fruit species, plums take second place in the world (Petri et al., 2018). Plum is most often used fresh, but it is also often processed (Felföldi et al., 2011), particularly drying, canning, making drinks (Birwal et al., 2016). The most well-known varieties of plums are Japanese and European, although the European plum is most often grown for commercial purposes (Zhebentyayeva et al., 2019). Beside, due to its chemical composition, the European variety of plum has a good effect on the preservation of human health

Regarding the great importance of the fruit sector, above all its economic character, the foreign trade of fruit varieties is subject to constant control of the conformity of production and consumption (Ostojić et al., 2019). The economic importance of plums production can also be described as an opportunity for the entrance to the new global markets by which is encouraged the development of entrepreneurship and the national economy (Prodanović, 2015; Nedeljković, 2021).

In Serbia, the largest fruit growing areas are owned by family agricultural holdings that need new investments in order to increase yields and improve soil quality (Mihailović et al., 2008; Grujić et al., 2012), and the dominant fruit variety is the plum. According to the SORS data, in period 2013-2022 an average of 73,438.8 ha was under plum or 42.3% of the area under orchards (eletronical database; agriculture, forestry, fisheries; crop farming). In second place are apples with an average of 25,573.8 ha and 14.7% of the total area under orchards. The third place is dominated by areas under grapes with an average area of 20,676.5 ha and 11.9% of the area under fruit crops. Raspberries and cherries follow, while the smallest area is occupied by walnut plantations with 3,440.3 ha (2%) and quince with 1,882.8 ha (1.1%). In the analyzed ten-year period, the areas under orchards accounted for an average of 5% of the total utilized agricultural area (UAA) (SORS, eletronical database, Census of Agriculture 2012, Farm structure 2018).

Many authors have researched the dependence of countries on the import of various foodstuffs and fresh materials, the degree of self-sufficiency and consumption per capita. Belmahi et al., (2023) have researched the dependence on grain imports in Morocco and found that this country became dependent on food grain imports (IDR = 39.8%) in the decade 2010-2020.

SSR has been researched by authors Brankov and Matkovski (2022). The authors analyzed the SSR of selected plant crops and products of livestock origin in the countries of the Western Balkans. Other authors also analyzed the degree of food self-sufficiency (Slaboch and Kotyza, 2016; Kubala and Stanuch, 2021). Belmahi et al., (2023) emphasize that Morocco has reduced the rate of food self-sufficiency in the last decade (2010-2020), because SSR = 66.72%.

When it comes to the analysis of food consumption per capita, data from the website *Statista* were analyzed. Food products for nutrition were divided into 13 groups. According to their reports, during 2022 year, the population consumed the most Bread and Cereal Products with 78.48 kg/per capita, while the last ranked place was consumption of Fish & Seafood with 4.35 kg/per capita. According to the same resource, fruits and nuts group products were consumed 34.95 kg/per capita.

Material and method of work

The sources of data for the analysis are data from eletronical database of the Statistical Office of the Republic of Serbia (SORS), and the International Trade Centre. The review of the literature includes articles on relevant topics, with an additional analysis of the compatibility of the methodology used in the available literature with the methodology we apply in the paper.

The first step in the evaluation of statistical indicators of the basic characteristics of plums production in Serbia is based on the analysis of descriptive statistics in terms of area (ha), production (t) and yield (t/ha) in the period 2013-2022.

The second step involves the analysis of three indicators that should give us answers to the following questions:

- Has Serbia being dependent on the import of this fruit;
- Does sufficient quantities of this fruit for its own consumption is produced in Serbia;
- Fluctuations in plum consumption per capita (population estimates).

The answers to these questions were obtained using three statistical indicators, namely: Import dependency ratio (IDR); Self-sufficiency ratio (SSR); consumption per capita (Cpc). The mentioned coefficients were analyzed for the period 2013-2022, and were calculated using the initial equations.

The first statistical indicator (IDR) indicates how much of the available domestic food supply has been imported and how much comes from the country’s own production (expressed in %). The equation *(Equation 1)* for calculating the IDR have a following form (Belmahi et al., 2023):

$$\mathrm{IDR} = \frac{\mathrm{Imports}}{\mathrm{Production + Imports - Exports}} * 100 \qquad (1)$$

Negative results show that the country is a net exporter (Abdelmajid et al., 2021).

The second statistical indicator (SSR) shows whether domestic production can meet the needs of domestic consumption (expressed in %). The equation *(Equation 2)* for calculating the SSR have a following form (FAO, 2012):

$$SSR = \frac{\text{Production}}{\text{Production} + \text{Imports} - \text{Exports}} * 100 \qquad (2)$$

According to authors' Brankov, Matkovski (2022) the countries with SSR < 100 produce less food than they need. If SSR = 100, that means that the domestic food supply can satisfy domestic consumption. The countries with SSR > 100 produce more food than they consume.

The third statistical indicator (Cpc) shows the trend of plum consumption in Serbia per capita (expressed in t/per capita). The equation *(Equation 3)* for calculating the Cpc have a following form:

$$Cpc = \frac{\text{Production+Import+Export}}{\text{Estimated population}} \qquad (3)$$

The values obtained in this way indicate whether the per capita consumption of plums is increasing or decreasing.

Descriptive statistics methods were applied to the results of the aforementioned indicators, which are commented on in the rest of the text.

The third step in the evaluation of statistical data is based on the analysis of the export of this fruit variety in the period 2013-2022, both by quantity (expressed in tons) and by value (expressed in USD). In addition, an overview of the dominant countries importing fresh plums from Serbia, in terms of quantity and value, is also given.

Results and discussion

Calculations based on the ten-year average of area, production and yield under plum for all three characteristics show a downward trend, and the value of the average annual rate of change is in support of this (AARC) (Table 1).

Table 1. Dynamics of plum production indicators in Serbia (2013 – 2022)

Variable	Area (ha)	Production (t)	Yield (t/ha)
Average	73,438.80	465,808.90	6.35
Min.	72,024.00	330,582.00	4.60
Max.	76,805.00	606,599.00	8.00
St. dev.	1,619.00	93,868.93	1.23
AARC (%)	-0.67	-2.38	-1.65
Cv (%)	2.20	20.15	19.45

Source: Authors calculation according to the SORS data

The data from Table 1. show certain changes when it comes to the area, production and yield of plums in Serbia from 2013 to 2022. In the analyzed period, plums were grown on an average area of 73,438.8 ha, with an average production of 465,808.90 t and an average yield of 6.35 t/ha. The values of the coefficient of variation show that the largest oscillations are visible in production (Cv = 20.15%) and plums yield (Cv = 19.45%), while the smallest variability was recorded in the area under plums (Cv = 2.2%). If we observe at the AARC values, we notice that all three indicators show negative values, which means that during the observed period, the area, production and yield of plums decreased on average annually. Accordingly, the authors conclude that the reduction of the area, production and yield of plums could affect the reduced supply of plums for own consumption, so Serbia, as an alternative, would have to import larger quantities of plums than in the past period.

In the following of the paper, an analysis of statistical indicators (IDR, SSR, Cpc) was carried out in Serbia, and their values are presented in tabular form (Table 2).

Table 2. Dynamics of IDR, SSR and Cpc for plum in Serbia (2013 – 2022)

Variable	IDR (%)	SSR (%)	Cpc (t/per capita)
Average	0.21	104.74	0.06
Min.	0.05	103.14	0.04
Max.	0.73	105.92	0.08
St. Dev.	0.20	0.91	0.01
AARC (%)	10.72	-0.05	-1.65
Cv (%)	94	1	21

Source: Authors calculation according to the International Trade Centre date and SORS date

In Serbia, in the observed period, the average IDR was only 0.21%, while the remaining quantities were covered by domestic production. The lowest value of this coefficient was achieved in 2019, and the highest in 2018. (Table 2). If we observe values of AARC, we notice that the value of IDR in the observed ten-year period increased by 10.72% on average per year with a high rate of variability (Cv = 94%). Based on this coefficient, we conclude that Serbia is not dependent on the import of fresh plums.

Serbia achieves a high degree of self-sufficiency with fresh plums because it can produce more than the needs for domestic consumption. Given that the average value of SSR was 104.74%, this means that Serbia can export 4.74% of its production in the analyzed period. The lowest value of this coefficient was recorded in 2019, and the highest in 2021. (Table 2). If we see at the AARC values, we can conclude that the SSR in the observed ten-year period decreased by -0.05% on average per year with a very low rate of variability (Cv = 1%).

The average consumption of fresh plums per capita in Serbia in the observed period was 0.06 t. In other words, each resident of Serbia consumed an average of 60 kg of plums per year. The lowest consumption was recorded in 2017, and the highest in 2020. (Table 2). If we observe at the AARC values, we notice that the Cpc in the observed ten-year period decreased by -1.65% on average per year with a slight rate of variability (Cv = 21%).

In the following is an overview of the participation of certain indicators important for the sector of fruit growing and export of fresh plums from Serbia (Table 3).

Table 3. Dynamics of export of fresh plums from Serbia (2013 – 2022)

Variable	Export of fruit, total (t)	Export of fresh plums (t)	Share of export of fresh plums in total export of fruit (%)
Average	465,982.5	21,921.9	4.9
Min.	368,544.0	15,450.0	2.9
Max.	540,886.0	33,031.0	9.0
St. Dev.	57,803.5	5,024.9	1.6
Cv (%)	12.4	22.9	33.6

Source: Authors calculation according to the International Trade Centre data

The data from Table 3. show that in the observed period there is slight variability in the share of fresh plums exports in total fruit exports (Cv = 33.6%).

The export of fresh plums compared to the total export of fruit was the lowest in 2017, and the highest in 2013. (Table 3). In the observed ten-year period, the number of fresh plums exported decreased by -24.7%, while the total export of fresh fruit increased by 13.6%. Based on these indicators, it can be concluded that the total amount of fruit exports is increasing, while fresh plums are decreasing.

According to the data shown in Table 4. we notice that in the observed ten-year period, the total export of fruit increased by 1.4% on average per year, while the export of fresh plums decreased on average by -3.1% per year.

Table 4. AARC of export of fruits and fresh plums by quantity from Serbia (2013-2022) (%)

	Export of fruit	Export of fresh plums
AARC	1.4	-3.1

Source: Authors calculation according to the International Trade Centre data

An analysis of the countries that import fresh plums from Serbia and the countries from which Serbia imports fresh plums in a ten-year period showed that Serbia exports the largest number of fresh plums to Bosnia and Herzegovina, and imports from North Macedonia. Following of the paper presents the dynamics of import and export of fresh plums in Serbia from 2013 to 2022 period with the first five countries of the world (Table 5).

Table 5. Dynamics of import and export of fresh plums in Serbia (2013 – 2022)

Variable	Import (t)				
	North Macedonia	Italy	Spain	Bosnia and Herzegovina	Russian Federation
Average	456.76	54.53	26.69	82.68	36.20
Min.	2.17	3.47	0.74	20.00	12.01
Max.	2,563.65	199.02	61.86	242.03	101.07
St. Dev.	775.10	60.69	24.09	70.66	30.69
AARC (%)	30.31	44.46	46.32	-19.86	3.65
Cv (%)	169.69	111.30	90.28	85.47	84.78
Variable	Export (t)				
	Bosnia and Herzegovina	Germany	Austria	Russian Federation	Czech Republic
Average	2,490.65	3,074.66	1,488.47	7,048.20	1,521.35
Min.	683.73	215.84	225.63	1,212.94	688.59
Max.	5,852.70	6,567.25	2,927.06	18,259.86	2,833.28
St. Dev.	1,768.05	2,027.02	896.90	6,196.06	704.28
AARC (%)	17.00	12.69	3.65	-20.85	-7.08
Cv (%)	70.99	65.93	60.26	87.91	46.29

Source: Authors calculation according to the International Trade Centre data

In the observed period, Serbia imported the largest number of fresh plums from North Macedonia (456.76 t on average), and the least from Spain (26.69 t). The highest average annual growth rate of plums imports was recorded in Spain and amounted to 46.32%, while imports from Bosnia and Herzegovina decreased on average annually at a rate of -19.86%. Regarding the countries from which Serbia imports fresh plums, we notice that the coefficients of variation are very high.

In the observed period, Serbia exported the largest quantities of fresh plums to Russia (average 7,048.20 t), and the least to Austria (1,488.47 t). The highest average annual growth rate of plums exports was recorded in Bosnia and Herzegovina and amounted to 17%, while exports to Russia and the Czech Republic decreased on average annually at the rate of -20.85% and -7.08%, respectively. When it comes to the countries to which Serbia exports fresh plums, we notice that the coefficients of variation are very high, which means that the exported quantities deviate significantly from the average values.

Based on the International Trade Centre data, in 2022, Serbia exported fruit (group *08 Edible fruit and nuts; peel of citrus fruit or melons*) worth approximately USD 894.4 mln. The leading fruit importing countries from Serbia (according to their share in the total export of fruit from Serbia) in 2022 were: 1) Germany (18.7%); 2) Russian Federation (17.8%); 3) France (12.1%); 4) Belgium (6.4%) and 5) USA (5.7%). To the mentioned world countries, Serbia exported fruit worth approximately USD 542.6 mln, which accounts for about 60.7% of the total fruit export from Serbia.

According to the International Trade Centre data, Serbia ranks 14th in the world in terms of export value of fresh plums (product subgroup 080940) in 2022, and Serbia's exports represented 1.5% of world exports for this product.

Export of subgroup 080940 from Serbia in the ten-year period 2013-2022 was on average USD 13.1 mln and from USD 7.8 mln (2019) exports increased to USD 14.5 mln (2022), i.e., by approximately 86% (International Trade Centre).

In 2022, Serbia exported products (by value) from the subgroup 080940 mostly to Russia Federation with a share of 17.3% of Serbia's total exports for this product group, followed by the Bosnia and Herzegovina (16.5%), Germany (15.3%), Poland (9%), and Austria (8.9%). Serbia exported 67% of the total value export of products of subgroup 080940 to the first five countries of the world.

If we look at the quantity of exported products from subgroup 080940, we see that the largest import partner of Serbia is Bosnia and Herzegovina, which during 2022 imported as much as 5,853 t, which is 23.5% of the total export of Serbia in the world. The top five countries in the world (including Bosnia and Herzegovina) according to the quantity imported are: Germany with 4,157 t or 16.7%; Austria with 2,596 t or 10.4%; Russia Federation with 2,226 t or 9%; Croatia with 1,698 t or 6.8%. In general, Serbia exported 66.4% of the total export of products of group 080940 to the first five countries of the world.

Regarding export prices for product subgroup 080940, in 2022 Serbia was achieve an average export price of 685 USD/t, which is higher than the export price achieved on the world market (584 USD/t).

Conclusion

The analyzed characteristics of plums production in Serbia in the ten-year period (area, production and yield) showed a downward trend, which may affect the reduced supply of plums for consumption at domestic market and the increase in imports.

The results of statistical indicators (IDR, SSR, Cpc) shown that Serbia:

a. *is not dependent on the import of fresh plums,*
b. *achieves a high value of the coefficient of self-sufficiency, which is the reason of being recognized as the leading exporting country in the world,*
c. *plums consumption per capita records relatively high values (up to 80 kg / per capita in 2021).*

Regarding that in the observed period the total export of fruit increased, and the export of fresh plums decreased, we can conclude that this result was influenced by the decrease in area, production and yield in the same period.

Serbia records significant results in the export of fresh plums, both in terms of quantity and value. Serbia is recognized as an important plum exporting country, with the first five EU countries exporting almost 50% of the total value of fresh plums exports.

The current situation in the fruit growing sector shows that future development should be focused on even more intensive production, characterized by high yields and quality fruits.

Also, the favorable natural conditions in Serbia should be used to the maximum for the production of quality table plums. In this way, producers can make more profit, and consumers get quality table fruit.

The conducted research also has its limitations, which were not analyzed in this paper, and should be mentioned: industrialization level, exchange rate, employment, etc. Future research directions could include the indicators just mentioned, because each of them to a certain extent affects changes in fruit and plum growing.

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AFLATOXIN OCCURRENCE, DETERMINATION AND REGULATION

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Abstract

Aflatoxins are one of the most global well-known and common food contaminants. As a secondary product of molds metabolism, aflatoxins can contaminate a large number of different agricultural and food products, as well as feeds. It is estimated that about 25% of the world's contaminated with at least one mycotoxin. The entry of aflatoxins into the nutritional chain poses a global risk to public health of humans and animals. Due to its carcinogenic effect, a major negative impact on health of humans and animals, as well as the great impact on economic losses, aflatoxins make it exceptional a challenge for research around the world. The International Agency for Research on Cancer (IARC) included AFB1 in the first group by end of the second millennium, while AFB2, AFG1, AFG2 i AFM1 was grouped in same class in 2002 year. There is a need for continuous monitoring the appearance of aflatoxins in food, feeds and AFM1 in milk, with the aim of protecting the consumers from risks associated with their proven toxicity and the carcinogenic effects.

Key words: Mycotoxicosis, aflatoxin, aflatoxin M1, health safety of food and feed.

Introduction

Mycotoxins are secondary products of molds metabolism, which are synthesized by series of reactions catalyzed by enzymes from a large number of biochemically simple intermediate products of primary metabolism, (Kos, 2015). Mycotoxins are produced by toxic strains of fungi are found in food for humans and animals, (Chhaya et al., 2023). Worldwide, the possibility for the contamination of nutritional chain with mycotoxins is permanently present, with a serious impact on human and animals' health. The presence of a persistent risk from mycotoxins and their undesirable presence in food and feed, influenced that many countries have adopted a policy of rigorous controls. The global problems of mycotoxicosis are causing a health hazard, and the toxin-contaminated products losing economic value in the global food market. Therefore, mandatory for food industries to perform analysis on potentially contaminated commodities before the trade, **(**Schincaglia et al., 2023). Various physical, chemical, biological, and nano-particles based approaches are used for minimizing and management of aflatoxin in food crops. However, researchers are also progressing in the development of fungal resistant varieties through breeding and genetic engineering approaches but their outcome is still a major concern. Hence a combined approach of using resistant varieties along with recommended pre-and post-harvest practices should be followed by farmers and food industries to minimize and degrade the aflatoxin content in food crops and their derived products. Mycotoxins are considered one of the most important causes of nutritional stress (Ivetić et al., 2007a).

Molds that produce toxic metabolites - aflatoxins during growth are *Aspergillus flavus, Aspergillus parasiticus* (Kihal et al., 2023), *Aspergillus nominius* (Buzas et al., 2023), *A. minisclerotigenes, A. korhogoensis, A. aflatoxiformans, A. texensis, A.novoparasiticus* and *A. arachidicola* (Giacometti et al., 2023) The four major aflatoxins AFB1, AFB2, AFG1, and AFG2 are commonly found in a wide range of food commodities, AFB1 and AFB.2 are produced by *A. flavus* while AFG1 and AFG2 are produced by *A. parasiticus*, (Kumar et al., 2021). Authors reported that AFB1 constitutes the most harmful type of aflatoxins and is a potent hepato-carcinogenic, mutagenic, teratogenic and it suppresses the immune system. The synthesis of AFM1 occurs in the mammalian organism after the intake of contaminated feed with AFB1. Aflatoxins affect the quality of milk because cows metabolize AFB1 to form the monohydroxide derivative aflatoxin M1 (AFM1), which is secreted into cow's milk, and is highly resistant to thermal treatments such as pasteurization and freezing, (Alvarado et al., 2017). AFM1 is stable in raw milk and prepared dairy products. They mostly undergo undamaged pasteurization processes, cheese production, yogurt, sour cream and butter. During cheese processing, AFM1 with casein is linked to a specific complex that affects a higher concentration of this mycotoxin in cheese than in whey. However, contaminated whey with AFM1 is often used to feed young animals, (Chavarría et al., 2017). The presence of mycotoxins in cow's milk and dairy products is one of the most serious problems of producing a health-safe diet, as milk is a key source of nutrients for humans. The effect of aflatoxin on the organism of domestic animals depends on genetic, physiological and external factors, (Ivetić *et al.*, 2023). The biggest impact on cow's milk contamination is AFB1 with AFM1. Many authors report that the diet of cows with food containing AFB1, in milk toxin AFM-1 will appear in milk after 12-24 h, after consuming contaminated diet, and will disappear from milk after 3-5 days (lvetić et al. 2007b). Animal feed contaminated with aflatoxins can cause different acute and chronic diseases of animals: refusal of food, weight loss, decrease in immunity, cancer, decreased reproductive capacity and decreased production, and death. Secondary aflatoxicosis tends to introduce into the body a smaller amount of aflatoxin for a very long period, compared to those that lead to obvious signs of poisoning and a change in the immune system, (Ivetić et al., 2023). However, in this way, altered immune function makes the animal more susceptible to other infectious diseases. Aflatoxins suppress the immune system of humans and animals by acting on the cells responsible for boosting immunity, (Kumar et al., 2021). Currently, consumers are continuously exposed to low doses of AFM1, (Buzas et al., 2023).

Aflatoxin contamination in crops is a global threat that compromises the safety of food, feed, and also influences the agricultural economy and crop-dependent small-scale industries, (Kumar et al., 2021). Crops can be contaminated during the process of harvesting, storing, and transporting by the fungi and leads to the productions of several mycotoxins. Mycotoxins are produced by certain fungi as secondary metabolites and aflatoxin is one of them. Crops can be contaminated during the process of harvesting, storing, and transporting by the fungi and leads to the productions of several mycotoxins. Mycotoxins are produced by certain fungi as secondary metabolites and aflatoxin is one of them. Aflatoxin contamination in crops caused a serious threat to production, the food market, health, and economics.

Conditions for the growth and development of aflatoxins

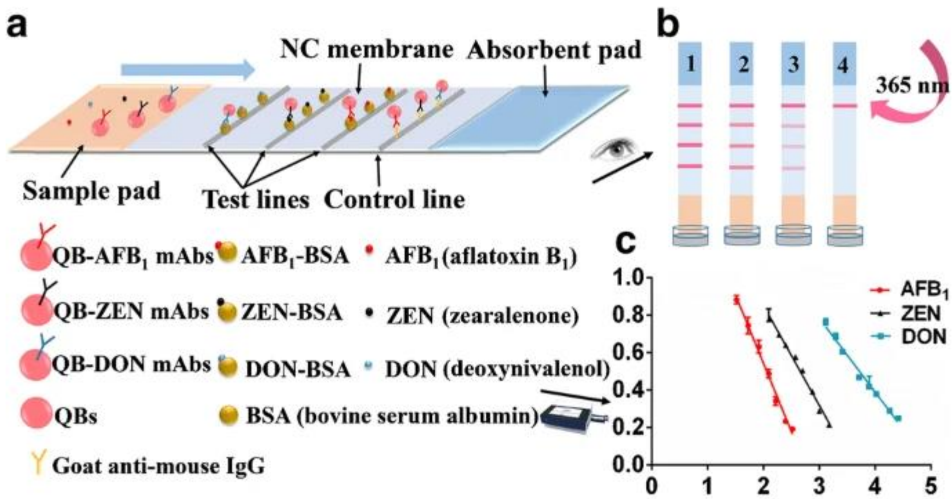
Physical factors like pH, light, moisture, temperature, water, relative humidity, and atmospheric gases are responsible for aflatoxin contamination. Aflatoxin-producing molds/Fungi can grow in a wide range of pH (1.7–9.3), but the optimum range of pH is (3–7), (Yoshinari et al., 2010). the water level does not have any reported effect on aflatoxin contamination. Aspergillus flavus poses an excellent survival capability to grow on a wide range of temperatures ranging from 12 °C to 48 °C, but 28 °C to 37°C is the optimum temperature range for its growth (Hawkins et al., 2005). Aflatoxins production can occur at a wide range of temperature; however, the optimal temperature for aflatoxin production is 25-35 °C (Siciliano et al., 2017). Normally at high temperatures, AFB production is higher than AFG, but at low temperatures both AFB and AFG production is equal (Matumba *et al.* 2015). Aflatoxins production and fungal growth are inhibited at a higher level of CO_2 and a lower level of O_2 (Mahbobinejhad et al., 2019).

Aflatoxin productions are also widely affected by the substrate and various nutritional factors such as carbon, amino acids, nitrogen, lipids, and few trace elements. Substrate rich in carbohydrates supports more production. The fact that mold *Aspergillus sp.* produce aflatoxins during their growth on substrates which are food for humans and feed for animals indicates their important influence on the occurrence of various mycotoxic diseases. Lipids also play an important role in aflatoxins production, (Kumar et al., 2021). Vitamins, amino acids, and metal ions also promote aflatoxin production. Amino acids like glycine, glutamate, and alanine along with some bivalent metals like zinc and magnesium promote aflatoxin production (Bolu et al., 2014). Amino acid such as tyrosine promotes aflatoxin production, while it is inhibited by tryptophan (Chang et al., 2015).

Biological factors include fungal species, weeds, and insect injuries. Weeds mostly grow as a competitor and cause plant stress which is associated with aflatoxin production. Pre-harvest contaminations of field crops are common because of the natural existence of *A. flavus* in soil, while post-harvest contamination also occurred by *A. flavus* during storage because it spoils the food grains.

Determination of aflatoxin, detection

Due to the fact that aflatoxins, as contaminants of food for humans and feed for animals, they are found in extremely low concentrations (µg/kg or ng/kg) at which they are expressed and toxic effect, their determination requires extremely sensitive and accurate methods. For the analysis of aflatoxins, various techniques can be used and different methods are used, which depends on the analyzed sample, availability of analysis equipment, training of the performer, concentration aflatoxin, speed, and other factors. In modern aflatoxin analytics (AFB1, AFG1, AFB2, AFB2, AFM1, AFM2) the greatest application has high-performance liquid chromatography (HPLC), (Schincaglia et al., 2023). It is also widely used immuno-enzymatic method ("enzyme linked immunosorbent assay", ELISA) as well as combined liquid chromatography technique with mass spectrometry (liquid chromatography-mass spectrometry, LC-MS/MS). It has been widely used in analytics aflatoxin also had thin-layer chromatography ("thin layer chromatography", TLC), which, due to the high values of the quantification limit and poor reproducibility, is almost in completely neglected, (Lin et al., 1998). In addition to the above techniques, for the purpose of rapid aflatoxin analysis, e.g., before storing grains in large silos, are also used so-called fast tests ("lateral flow") based on immunochromatographic principles (Reiter et al., 2009; Li et al., 2019), graph 1. The most common technique is ELISA for determining AFM1 in milk and dairy products, and HPLC and LC-MS/MS are increasingly used techniques (Shephard et al., 2013).



Graph 1. Fluorometric lateral flow immunoassay for simultaneous determination of three mycotoxins (aflatoxin B1, zearalenone and deoxynivalenol), Li et al., 2019

Contamination of AFM-1 during certain years in milk and dairy products depends on weather conditions in a given period due to the resulting climate change, frequency of control and precision of analytical techniques. It is defined many official methods to detect aflatoxin contamination in crop plants, which are featured by the Association of Official Analytical Chemists (AOAC) (Kumar et al., 2017). Amongst them, the most commonly used method is Enzyme-Linked Immunosorbent Assay (ELISA) followed by some chromatographic methods including High-Performance Liquid Chromatography (HPLC), Liquid Chromatography-Mass Spectroscopy (LCMS), and Thin Layer Chromatography (TLC) (Sulyok et al., 2016).

Mitigation of aflatoxin

Aflatoxins are synthesized by many fungi spp. including *Aspergillus, Penicillium, Fusarium*, and *Alternaria* but *Aspergillus flavus* and *Aspergillus parasiticus* are known to produce the most toxigenic strains of aflatoxins, (Kumar et al., 2021).

Aflatoxins have a significant health, nutritional and economic impact on the nutritional chain of humans and animals. All participants in the production and food chain such as farmers, grain producers, distributors, crop processors, farmers and consumers have consequently losses, (Ivetić et al., 2022). Direct effects include increased veterinary care costs, reduced livestock production and continued endangered food safety for humans and animal feed (Ćosić and Ivetić, 2022).

To minimize the aflatoxins contamination in crop plants, various physical, chemical, and biological methods, and various breeding and genetic engineering approach as well, has been used to minimize the toxicity of aflatoxin and reduce its level below the recommended one. Several approaches have been manifested to reduce the aflatoxin contamination in crops which include various physical, chemical, and biological methods.

Moisture is a significant factor in fungal growth which leads to the production of aflatoxin in crops. Physical methods such as steam under pressure, dry roasting, and other cooking methods are found to be effective in the control or to reduce the aflatoxin contamination in many crops (Peng et al., 2018). Reduction of aflatoxin in the range of 40–73% was observed by heating the seed samples on 180 °C (Opoku, 2013). When groundnut and corn seed was roasted with 30% moisture at 100 °C temperature for 2 h, there is a reduction of aflatoxin by 70 and 79% AFB1 and AFG1(Jalili, 2016), and by 85% (Leong et al., 2010), when the seeds are roasted at 150°C for 15 min.

Several chemicals such as acids, alkalis, oxidizing agents, aldehydes, and several gasses are also proved to mitigate the aflatoxigenic fungal growth and aflatoxin production when used in appropriate quantity (Udomkun et al., 2017). Among gasses, ozone was found to be most effective in maximizing the aflatoxin degradation on legumes and cereals by an electrophilic attack on carbon bonds of furan ring (Jalili, 2016). Certain chemicals such as sodium bisulfite, calcium hydroxide, formaldehyde, sodium hypochlorite, sodium borate, and sorbents also reduce the aflatoxin in many food commodities at a significant level (Carvajal and Castillo, 2009).

Some food additives are also used for the inhibition of fungal growth and aflatoxin production in combination with some physical factors like temperature and moisture. Treatment of citric acid in conjunction with high temperature and pressure leads to the inhibition of fungal growth as well as aflatoxin production in sorghum (Méndez-Albores et al., 2009). Some scientists also observed that some food preservatives such as propionic acid, crystal violet, p-amino benzoic acid, benzoic acid, boric acid, and sodium acetate were also inhibited the A. flavus growth and aflatoxin production (Aiko and Mehta 2015).

Biological methods can mitigate the aflatoxin contamination in agricultural products and many other food commodities such as the use of various microorganisms. Biological agents such as bacteria, yeasts, molds, and algae exhibit the different potential to degrade the aflatoxin in the emulative environment. Detoxification of aflatoxins by using biological agents is divided into two procedures named absorption and enzymatic decadence (Jard et al., 2011). Different types of absorbents that can act as a potential binding agent for aflatoxin have been studied (Kihal et al., 2023, Ivetić et al., 2007b). Aflatoxins can be absorbed by microorganisms directly either by concatenating to their cell wall contents through effectual internalization or congregation (Motawe et al., 2014). Aflatoxins can also be absorbed by dead microorganisms; this ability can be helpful for the fabrication of bio-filters in the form of probiotics and found application in fluid decontamination (Mwakinyali et al., 2019). Degradation of aflatoxins can also be done by intra or extracellular enzymes; the end products of such enzymatic degradation are mostly water and CO_2 (Aliabadi et al., 2013).

Legal regulations

Both toxins, AFB1 and AFM1 are carcinogenic. However, AFM1 is the most toxic secondary metabolite secreted in milk and is classified as group 1 carcinogenic by the International Agency for Research on Cancer (IARC, 2002). As such, AFM1 poses a global health risk to food safety for humans and animals. Regulation (EC) No 1881/2006 sets a maximum limit of 0.05 μg/kg for AFM1 in raw milk, heat treated milk and milk for the production of milk-based products (European Commission, EC/1881/2006). The same limit was valid in Serbia from 2011 (Official Gazette of RS, 28/2011) until the end of February 2013.

However, after the appearance of contamination of milk with AFM1 in Serbia at the end of February 2013, the Government of Serbia established a new maximum level at 0.25 μg/kg of milk. The permissible level of aflatoxin (AFM1) in milk in Serbia, five times higher than in the European Union and may be reduced at the end of 2023, according to the Regulation amending the Regulation on maximum concentrations of certain contaminants in food (Official Gazette of the Republic of Serbia, No. 127/2022). The amendment of the Regulation on maximum concentrations of certain contaminants in foodstuffs (Official Gazette of the Republic of Serbia, No. 81/2019, 126/2020, 90/2021, 118/2021 and 127/2022) provides for the lowering of the permitted levels of this substance from 1 December 2023, Table 1.

Table 1. Permitted levels of aflatoxin contamination in foodstuffs, Regulation on maximum concentrations of certain contaminants in foodstuffs (Official Gazette of the Republic of Serbia, No. 81/2019, 126/2020, 90/2021, 118/2021 and 127/2022)

No	**Food**		**Maximum permissible concentration (µg/kg)**		
			B_1	**Amount B_1, B_2, G_1 i G_2**	**M_1**
2.1.13.	Raw milk, thermally processed milk and milk for the production of dairy products	Until 30 November 2023.	-	-	0,25
		As of December 1, 2023.			0,050

Regulation on the quality of feed (Official Gazette of the Republic of Serbia, No. 4 /2010, 113 /2012, 27 /2014, 25 / 2015, 39 /2016, 54 /2017), more closely prescribes the conditions regarding the quality of feed. The limits of the levels of AFB1 in feedstuffs, complementary and complete mixtures for animals, are prescribed in Article 99 of this Regulation and are shown in Table 2. Feed, for the purposes of this Regulation, means products of plant, animal and mineral origin, produced naturally or industrially, which are used for the nutrition and production of premixes and mixtures.

It should be noted that as long as the parent compound AFB1 is not controlled both in food and in feed, it cannot be expected that only control of AFM1 exposure cannot be expected to lead to a significant global reduction in hepatocellular carcinoma (liver cancer), (Turna et al., 2022).

Chhaya et al., (2023) states that in the European Union the maximum permitted level of aflatoxin B1 in feed is 0.02 mg kg^{-1} (moisture content 12%) or 20,000 ng kg^{-1}, with a maximum allowable content in concentrated feed for dairy cows of 0.005 mg kg^{-1} (moisture content 12%) or 5000 ng kg^{-1} (Directive 2002/32/EC).

Farm productivity problems caused by toxins can be prevented (Ivetić *et al*, 2013). Early and rapid detection of aflatoxin M1 by applying a strict self-control strategy resulting in the application of mitigation measures can significantly reduce the concentration of aflatoxin M1 in milk, (Giacometti et al., 2023).

Table 2. Limits of permitted levels of AFB1 in feed, supplementary and complete mixtures for animals, (Regulation on the quality of feed, Article 99, Official Gazette of the Republic of Serbia, No. 4 /2010, 113 /2012, 27 /2014, 25 / 2015, 39 / 2016, 54 /2017)

Undesirable substances	**Products intended for feed**	**Maximum allowable amount expressed in mg/kg (ppm), when the moisture content of feed is calculated at 12%**
Aflatoksin B1	Feeds	0,03
	Complementary and complete mixtures	0,01
	Except:	
	– mixtures (complementary and complete) for dairy cows and calves, dairy sheep and lambs, milk goats and goats, piglets and young poultry	0,005
	– Mixtures (complementary and complete) for cattle (excluding dairy cows and calves), sheep (except dairy sheep and lambs), goats (except dairy goats and goats), pigs (except piglets) and poultry (except young animals).	0,02

Conclusion

Aflatoxins have a significant health, nutritional and economic impact on the nutritional chain of humans and animals. There is a need for continuous monitoring the appearance of aflatoxins in feeds and AFM1 in milk, with the aim of protecting the risks associated with their proven toxicity and the carcinogenic effects. Worldwide, the possibility of contamination of the food chain with mycotoxins is permanently present, with a serious impact on human health. The presence of a persistent danger of mycotoxins and their undesirable presence in food affects that many countries have adopted a policy of rigorous controls. Therefore, ELISA methods, as well as Liquid Chromatography methods with different detectors (HPLC-FLD, HPLC-UV light-FLD, LC-MS/MS) are developed and optimized for the implementation. If the primary toxin AFB1 is not controlled in both food and feed, controlling AFM1 exposure cannot be expected to lead to a meaningful global reduction. In the long term, regular farm to fork aflatoxin monitoring should be an essential tool in order to prevent the lowest aflatoxins levels in food and feed.

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INFLUENCE OF EFFECTIVE MICROORGANISMS ON THE DIAMETER OF THE CAP AND MASS OF MUSHROOMS (*Agaricus bisporus*)

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Abstract

Mushrooms, due to their nutritional value, are increasingly included in people's diets. A small number of species are cultivated commercially in the world. There is also not a lot of research related to mushroom cultivation technology. The goal of the work was to determine the application of effective microorganisms in the production of champignon mushrooms in briquettes. EM Aktiv preparation is used in two treatments. In treatment EM1, compost was sprayed in the briquettes after mycelium sowing. Peat used as mulch was also sprayed twice. In the course of cultivation, spraying with water mist with the addition of preparations was carried out. In the EM2 treatment, only the initial treatment of compost and peat was carried out. The diameter of the champignon cap and the weight of the champignon were measured in each harvest (5 harvests in total). The diameter of the cap showed statistically significant differences only in dependence on the harvest term. With the length of the growing time, the diameter of the mushroom cap also increased. Mushroom mass was statistically highly dependent on treatment and harvest time. In treatment EM 1, an increase in the mass of champignons was determined by 19.97% compared to the control, and in treatment EM 2 by 0.04%.

Key words: Mushrooms, effective microorganisms, diameter of the mushroom cap, mass of mushrooms.

Introduction

Mushroom cultivation is one of the fastest growing and most promising agricultural sectors. Mushroom cultivation has advantages due to low production costs, and return value in a short period (Ahmad Zakil et al., 2020). Due to the increase in world population, the demand for fresh mushrooms has also increased. Although about 2,000 species are known to be true edible mushrooms of superior quality, only 35 species are commercially grown (Rathore et al., 2017). In addition to nutrition, mushrooms are used as dietary products that can help in the treatment of various degenerative disorders (Ma et al., 2018). Mushroom-based products are used in traditional Chinese medicine in acupuncture and for chiropractic purposes. The types of mushrooms that are grown the most are champignons (*Agaricus biisporus*), oyster mushrooms (*Pleurotus sp.*), then the Japanese shiitake mushroom (*Lentinus edodes*), and the rice straw mushroom (*Volvariella volvaceae*).

Agaricus bisporus is a type of mushroom - champignons that are most represented in commercial production. The largest producers of champignons in the world are China, Japan, the USA and the Netherlands, and in Europe Poland and Spain are significant (www.fao.org/faostat/en/).

The level of champignon production in Serbia is increasing year by year. The average production of champignons in the period 2006-2020 was 5,050.70 tons with an increase of 37.1%. The chemical composition of mushrooms determines their nutritional value and organoleptic properties, and it differs depending on the type of mushroom, the substrate on which it grows, atmospheric conditions, age and stage of collection.

According to the chemical composition of champignons, it can be said that they are a dietary product. In 100 g of fresh mushrooms, there are 3.09 g of protein, 3.26 g of carbohydrates, 0.34 g of fat and 1 g of fiber. In addition to essential amino acids, mushrooms also contain significant amounts of lysine, alanine, arginine, glycine, histidine, glutamic acid, aspartic acid, acids, proline and serine. In addition, champignons have an antioxidant effect because they are carriers of phenol derivatives, β-carotene, tocopherol, and ascorbic acid.

For the successful production of champignons, a good source of nitrogen, pH, temperature and humidity of the environment must be provided (Bellettini et al., 2019). Limiting factors are the limited selection and supply of biological pest control products that can be applied throughout the growing process (Rosmiza et al., 2016).

With the development of awareness about health-safe food, research on the possibility of mushroom production using effective microorganisms as growth stimulators and preventive protection against diseases is very important.

Effective microorganisms (EM) are an example of a supplemental compound that can be used in mushroom production. EM is defined as mixed cultures of microorganisms that provide natural benefits when applied as an inoculant in the soil ecosystem, while in mushroom cultivation it is an additive to increase microbial diversity in the substrate (Joshi et al., 2019). This group of microorganisms has an appropriate role in preventing the occurrence of green mold disease (Potočnik et al., 2015; Joshi et al., 2019). The application of EM in the agricultural industry is no longer new. However, it is still relatively new in mushroom cultivation applications.

The aim of the work was to determine the influence of preparations with EM on the diameter of the cap and the weight of the mushroom *Agaricus bisporus*.

Material and method of work

Research was carried out in 2022 in the chambers of Delta Danube d.o.o. Kovin, which is engaged in the production of champignons *Agaricus biisporus*. In the premises, the average air temperature was maintained at 21.8°C; average compost temperature 25.1°C; air humidity about 80%. The peat briquettes were seeded with fungal spores. After 17 days of incubation, the briquettes were opened and covered with a 5 cm layer of peat.

The experiment was set up as a two-factorial (factor A harvest time; factor B treatments). The treatments were applied according to the schedule in Table 1. For the spraying treatments, a microbiological preparation with effective microorganisms EM Aktiv (commercial name) was used.

Control briquettes are filled with standard technology used in production. Three briquettes were prepared for each treatment.

Table 1. Method of application of the tested factors

Treatments	28. 04. 2022.	29 .04. 2022.	01. 05. 2022.	03. 05. 2022.	04. 05. 2022.
EM 1	Compost: 50 ml EM+0.5 l H_2O Peat: 2 l H_2O/m^2	1 l H_2O/m^2	1.5 l H_2O/m^2	1 l H_2O/m^2	Compost: 100 ml EM+ 1.5 l H_2O
EM 2	Compost: 100 ml EM+1 l H_2O Peat: 2 l H_2O/m^2	1 l H_2O /m^2	1.5l H_2O/m^2	1 l H_2O / m^2	2.5 l H_2O/m^2
Control	2 l H_2O/m^2	2 l H_2O /m^2	0.5 l H_2O/m^2		2 l H_2O/m^2

During the cultivation, the briquettes were sprinkled with a fine mist of water to prevent them from drying out. During dewing, when the mushrooms were the size of peas in EM 1 treatment, 30 ml of EM Aktiva was added (Tabela 2).

Table 2. Scheduling for briquette sprinkled

Treatments	11 .05. 2022.	12. 05. 2022.	13. 05. 2022.	14. 05. 2022.	15. 05. 2022.	16. 05. 2022.
EM 1			0,5 l H_2O /m^2		EM 30 ml + 0.5 l H_2O	1 l H_2O/m^2
EM 2			0.5 l H_2O /m^2		0.5 l H_2O/m^2	1 l H_2O/m^2
Control	0.5 l H_2O/m^2	1 l H_2O /m^2	0.5 l H_2O/m^2	1 l H_2O/m^2	1 l H_2O /m^2	1 l H_2O/m^2

The harvest took place in five dates from May 18. 2022. until May 27. 2022 (Figure 1). At each harvest, the diameter of the cap and the weight of the champignons were measured. Samples for measurements were taken along an imaginary diagonal line per briquette (Figure 2).

Figure 1. Day zero of mushroom picking

Figure 2. An imaginary sample line

The first harvest is 20 days after covering, and the larger harvest is between the 22nd and 25th day after covering. Harvesting takes 4 - 5 days and is done manually. In that period, ventilation is very important, since mushrooms "breathe", which means that they produce large amounts of CO2, which must be expelled through the ventilation system. Otherwise, the color of the hat changes and the mushroom ripens faster, which results in a loss of quality and quantity. Mushrooms (champignons) are harvested at the stage of technological maturity, i.e. when the membrane is tight, while the fruits are still firm and closed. Maturity is judged by how tight the skin under the hat is, not by the size of the mushroom. Ripe champignons are both large and small, and the best size for placing them fresh is 3 to 5 cm. When about 70% of the wave is harvested, you should start watering for the second wave. If it is known that 90% of the champignon fruit is water, by picking 100 kg of mushrooms, 90 liters of water are taken from the substrate, and that much must be compensated before the second wave, within 2 - 3 days. Before the start of the formation of the second wave, cleaning is carried out, which involves removing the remains from the stalks, as well as from small, damaged, rotten and dead mushrooms. On such a detailed surface of briquettes, new individuals can be expected in 2 - 3 days, and in 5 - 6 days a new wave of harvesting. The cycle repeats itself and champignons can be harvested as long as they give birth, i.e., as long as there are nutrients in the compost.

Results and discussion

Successful production depends on external factors (temperature, moisture, light, substrate, air) and internal factors (genetic production potential). Requirements for water: During the incubation phase, it is necessary to maintain the air humidity at about 80%, the compost is not watered during this time, because it already contains the necessary moisture (about 70%). When the cover is reached, the peat should then have a relative humidity of about 75%, which should be maintained until the end of the cycle. In the cooling phase, the relative air humidity should be increased to about 88%, which should be maintained until the end of the cycle.

Temperature requirements: The temperature requirements of mushrooms (mycelium) are different, depending on the stage of development in which they are. Thus, while it is in the stage of incubation and covering, the temperature of the compost should be 25-26°C, and it should never exceed 27°C, because this leads to a decrease in fertility and the appearance of some diseases, and at temperatures of 30°C and above, the mycelia dies. As for the air temperature in these phases, it should be maintained at the level of 19 °C to 23°C, which depends on the activity of the compost, the season and the conditions in the nursery. It is a condition for the formation of nodules, ie. future fruits. This temperature is maintained until the end of the cycle.

Light requirements**:** Direct light does not interfere with the growth of mushrooms, but to a certain extent it can cause increased drying of the production areas, it can affect a certain change in the temperature regime in the nursery, then it can cause changes in the color of the fruiting body and thus reduce the quality, and it can also accelerate the development the causative agent of some diseases and pests. With all that in mind, mushroom production should be organized in dark rooms, because that's where the best yields and quality are achieved.

The diameter of the cap defines the category of champignons and significantly affects the total mass. The average diameter of the cap was 47.03 mm (Table 3). Factor A had a highly significant influence on the diameter of the cap, because with the increase in the number of days, the diameter of the cap also increased. The largest diameter of the cap was determined on the last day of harvest in the EM 1 treatment, and the smallest in the control on the first day of harvest. By applying treatment with EM, differences in the diameter of the cap were determined, but they were not statistically significant compared to the control.

Table 3. The diameter of the mushroom cap depending on the treatment (mm)

Dates of picking (A)	**Treatments (B)**			**Factor A**
	EM 1	**EM 2**	**Control**	
18.05.2022.	46.49	47.67	41.06	**45,07**
20.05.2022.	45.88	45.28	45.55	**45.57**
22.05.2022.	47.64	46.76	47.55	**47.32**
24.05.2022.	48.29	47.07	47.84	**47.73**
26.05.2022.	50.25	48.62	49.55	**49.48**
Factor B	**47.71**	**47.08**	**46.31**	
Average				**47.03**

	A **	B	A x B
F test	0.00	0.36	0.37
$LSD_{0.01}$	2.71	2.37	5.30
$LSD_{0.05}$	1.86	1.74	3.89

At each harvest, the weight of the mushrooms was measured. Based on the results, a highly significant influence of the examined variables and their mutual relationship on the mass of champignons can be observed. The average weight per harvest day was 1,507 kg (Table 4). In both treatments, a difference in the yield of mushrooms was determined, which is statistically highly significant compared to the control. In the EM 1 treatment, the mass of harvested champignons on a daily basis was 83.92% higher than in the control, and in the EM 2 treatment, it was 53.30% higher. The mass of champignons increased with the number of days. The highest mushroom mass was in the first treatment on the last day of harvest, and the lowest in the control on the first day of harvest. The obtained results are compatible with the mushroom cap diameter results. According to the mass and width of the cap, it was observed that the champignons in the EM 1 treatment were ready for harvesting earlier than in the EM 2 and control treatments. The obtained results are compatible with the researches of others. Wang et al., (2021) analyzed the influence of mushroom growth on the microbial activity of the substrate and determined that with mushroom growth there are changes in the composition and activity of the microbial community in the substrate, which leads to more intensive mushroom growth. According to Familoni et al., (2018) during the growing period, mushrooms interact with different groups of the microbial community that accelerate the compost mineralization process leading to a change in the composition of the substrate.

Table 4. Average yield of harvested champignons (kg)

Dates of picking (A)	**Treatments (B)**			**Factor A**
	EM 1	**EM 2**	**Control**	
18.05.2022.	0.068	0.072	0.052	**0.064**
20.05.2022.	0.744	0.780	0.665	**0.730**
22.05.2022.	2.159	1.944	1.884	**1.996**
24.05.2022.	3.026	2.226	2.154	**2.469**
26.05.2022.	3.043	2.515	2.779	**2.779**
Factor B	**1.808**	**1.507**	**0.983**	
Average				**1.507**
	A**	B**	A x B**	
F test	0.00	0.00	0.00	
LSD $_{0.01}$	0.36	0.20	0.44	
LSD $_{0.05}$	0.25	0.14	0.32	

The total mass of champignons for all five harvests was 24,144 kg (Table 5).

Table 5. Total yield of champignons (kg)

Yield	**Treatments**			**Total**
	EM 1	**EM 2**	**Control**	
In total	9.039	7.537	7.534	24.144
Deviation %	19.97	0.04	100	

The highest mass of harvested champignons was 9,039 kg in the EM 1 treatment, which was 19.97% more than in the control. In the EM 2 treatment, the total mass of harvested mushrooms was 0.04% higher than in the control.

Mushroom cultivation is important for sustainable production systems. According to Zhang et al., (2014) after mushroom harvesting, a large mixture of mycelial residues, carbohydrates and nutrients (bacterial proteins and minerals) secreted by microbes remains in the substrates. which is a valuable agricultural renewable resource. Some studies have shown that mushroom residues are not only a by-product, but also a compostable resource that can be applied as an organic fertilizer (Tangjuan et al., 2016).

Conclusion

Based on the research results, it can be concluded that the application of effective microorganisms had a significant impact on the growth and yield of champignons. The industrial production of champignons with the application of effective microorganisms has an advantage from the ecological aspect of the production of health-safe food.

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EFFECTS OF ENTERIC METHANE MITIGATION PRACTISE

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Abstract

The paper gives an overview of nowadays aspects of enteric methane emission with the aim to pointing out the importance of climate change mitigations practice. Enteric methane is formed as a by-product of digestion of feed, primarily at ruminants by enteric fermentation. Ruminants emit methane created by enteric fermentation in the rumen, mostly by eructation. Nutritional interventions to mitigate enteric methane (ECH_4) have been thoroughly investigated and many innovative solutions are being tested and considered. To meet the increasing demand for meat and milk, the livestock industry has to increase its production, which is followed with the increasing the ECH_4 emission. Continuous research and development are needed to develop ECH_4 mitigation strategies that are locally applicable. Climate change mitigation and adaptation policies play a crucial role in the political agendas of local authorities who has to support the development and implementation innovative products or methods for ECH_4 mitigation. Addressing these challenges after local levels, requires collaboration among many organizations and across different sectors, followed by cross-border and worldwide cooperation.

Key words: Enteric methane, ruminant nutrition, greenhouse gases, mitigation.

Introduction

Air pollution depends on many natural and human factors, and the variation of pollutants and weather changes modify the concentration of pollutants in time and space (Battista et al., 2017). To meet the increasing demand for meat and milk, the livestock industry has to increase its production, and without improving its efficiency, raised livestock, especially ruminant animals, will worsen the environmental damage, mainly from enteric CH4 emission (Wang et al., 2023). Diary organizations worldwide announced greenhouse gas neutrality goals. Mitigation of enteric methane emissions is necessary to achieve these goals. Many innovative solutions are being tested and considered. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations and across different sectors, followed by cross-border and worldwide cooperation.

Global climate change is affecting temperature, precipitation, and water availability, which directly affects agriculture and livestock productivity (Souza et al., 2023). Therefore, the expected decline in dry matter intake (DMI) and animal productivity and changes in water intake caused by heat stress may also affect the environmental costs of production in cattle. With the current interest in reducing CH_4 emissions in ruminant production systems to limit global warming (Arndt et al., 2022), models that predict CH_4 emissions have become an important tool to evaluate mitigation strategies (Niu et al., 2018), when other technologies are not available to measure individual enteric CH4 emissions, (Souza et al., 2023). The agricultural sector is faced with challenges related to global warming and climate change, which affect human and animal food security. Due to climate change, periods of drought might be longer and occur more frequently, which challenges roughage production and requires changed feeding of dairy cattle by increasing the grain content of the diet, (Ivetić et al., 2023; Olijhoek et al., 2022). Also, the feeding behavior of cattle could be managed in more effective manner, (Ivetić et al., 2008, Ivetić et al., 2007). Land plays a key role in the global cycles of GHG (i.e., carbon dioxide (CO2), methane (CH_4), and nitrogen oxide (N_2O), and land use change can lead to the release of such gases into the atmosphere or the removal of them from the atmosphere, (Huang et al., 2023). One of the most common forms of land use change is agricultural land conversion where agricultural lands are converted for other uses. Huang et al., (2023) reported that increasing agricultural land conversion to more than 8 % of available land led to increasing GHG emissions during the economic development process.

Livestock enteric CH_4 mitigation is an old feed energy efficiency problem with new dimensions, (Hristov et al., 2022). Governments and the public are interested in finding solutions to climate change, and it is believed that mitigation of agricultural greenhouse gas (GHG) emissions is part of the solution (US Government, 2021). In the United States, agricultural activities are responsible for the generation of GHG such as CO_2, CH_4, and N_2O, with the latter 2 gases being of primary interest: agriculture contributed 39% (CH_4) and 80% (N_2O) of their total emissions in 2019, on a CO_2-equivalent basis (USEPA, 2021). Within agriculture, livestock is responsible for 94% of all CH_4 emissions in the United States (USEPA, 2021).

Continuous research and development are needed to develop enteric CH_4 mitigation strategies that are locally applicable, also information is needed to calculate the carbon footprints of interventions on a regional basis to evaluate the impact of mitigation strategies on net greenhouse gas emissions, (Beauchemin et al., 2022).

Enteric methane

Enteric methane is a major source of greenhouse gas emissions from milk and beef production systems that contribute to global warming, (Tricarico et al., 2022). Enteric fermentation is the second largest source of methane emissions after natural gas and petroleum systems, and the second largest source of agricultural greenhouse gas emissions in the United States after nitrous oxide emissions from managed soils (US EPA, 2021), Figure 1.

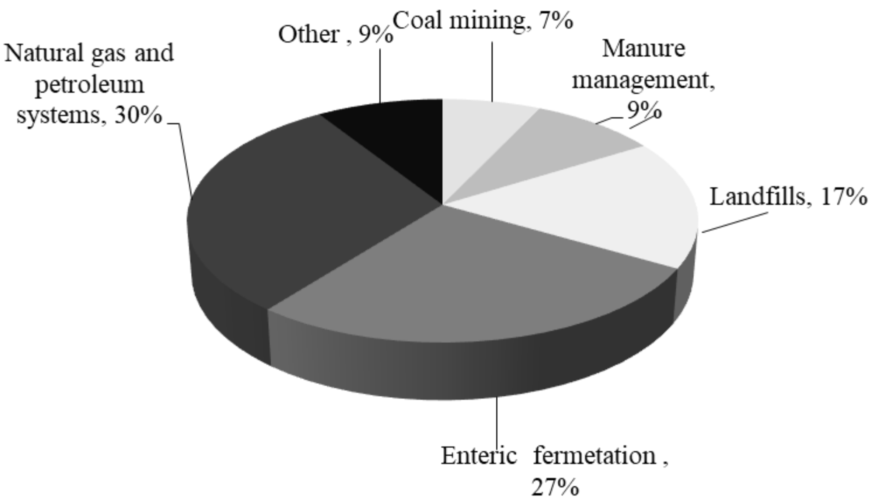

Figure 1. US methane emission by source, EPA 2020

Methane is estimated to have a global warming potential, global warming potential (GWP), 28–30 more than carbon dioxide over a hundred-year period, by the United States Environmental Protection Agency (EPA, 2021, and Intergovernmental Panel on Climate Change - IPCC, Table 1. In Europe, 81% of agricultural methane emissions result from enteric fermentation, and 39% of those 81% are produced by dairy cows, (EEA, 2020).

Table 1. IPCC Sixth Assessment Report Global Warming Potentials,2021

Greenhouse Gas	100 Year Time Period			20 Year Time Period		
	AR4 2007	AR5 2014	AR6 2021	AR4 2007	AR5 2014	AR6 2021
CO_2	1	1	1	1	1	1
CH_4 fossil origin	25	28	29.8	72	84	82.5
CH_4 non fossil origin			27.2			80.8
N_2O	298	265	273	289	264	273

In the AR6 report, an additional GWP for methane has been included to differentiate between methane which originates from fossil fuel sources, and methane from non-fossil fuel sources, like agriculture

Unlike other sources of greenhouse gas emissions, such as those from fossil fuel extraction and distribution that only contribute to atmospheric greenhouse gases, milk production systems are part of the biological carbon cycle and can function as a sink for greenhouse gases, thereby contributing to reverting climate change, (Le Quéré et al., 2018). Because emitted methane is continuously removed from the atmosphere by hydroxyl oxidation, its atmospheric warming effects depend on the rate of emissions increase or decrease over the last 20 years rather than the total cumulative amount emitted over that period, (Allen et al., 2018). *Tricarico et al.,* (2022), have the opinion that if mitigation of enteric methane production greater than 0.3% annually that is sustained over time (i.e., year-over-year) could be used to offset the atmospheric warming effects of carbon dioxide and nitrous oxide emissions from milk production systems. In this way, sustained mitigation of enteric methane production becomes a valuable tool for dairy value chains to meet their greenhouse gas reduction goals. Therefore, a significant reduction in methane emissions, particularly from agricultural activities, would rapidly mitigate climate change and is a powerful lever to meet the European Union's 2050 climate targets (Dupraz, 2021).

Gloux et al, (2023) highlight that the Intergovernmental Panel on Climate Change (IPCC) defines 3 different methods, to be applied to national inventories according to data availability:

- Tier 1 methods attribute default yearly enteric methane emissions factor per dairy cow. Tier 1 methods provide aggregate estimates, and are not adequate for monitoring changes over time and taking into account the variability of dairy farming practices;
- Tier 2 methods improve the accuracy of emission factors by including feed intake estimates of a representative diet and dairy cow;
- Tier 3 methods require a precise characterization of cows' diet to account for digestibility;

Aspects of cost of implementing mitigation strategies has to be considered, for the adoption of mitigation strategies for livestock GHG emissions. Climate change mitigation and adaptation policies play a crucial role in the political agendas of local authorities who has to support the development and implementation innovative products or methods for ECH_4 mitigation.

Mitigations methods

The amount of ECH_4 that is released depends on the type of digestive tract, age, and weight of the animal, and the quality and quantity of the feed consumed. Ruminant livestock (e.g., cattle, sheep) are major sources of ECH_4 (Ivetić et al., 2022a, Ivetić et al., 2022b, Ivetić et al., 2021) with moderate amounts produced from non-ruminant livestock (e.g., pigs, horses). World demand for animal-sourced foods and global warming concerns rise, safe and effective strategies for enteric methane mitigation in dairy cows are in high demand and De Ondarza et al., (2023) created the dataset from data collected from scientific publications identified through searches of the scientific literature for the greenhouse mitigations effects. The bibliography used by Arndt et al., (2022), covers the period from 1963 to 2018, and De Ondarza et al., (2023), supplemented with literature searches to cover the period between 2019 and 2022. Information from 797 treatments was organized in rows and 162 columns containing variables, including experimental design, animal definition, methane measurement method, dietary nutrients, and treatment responses. Mitigation strategies were classified into 3 main categories: animal and feed management, diet formulation, and rumen manipulation, and up to 5 subcategories (Hristov et al., 2022). This large dataset with descriptive data and treatment means from in vivo dairy cow enteric methane studies can be used by public and private researchers and advisors including nutritionists, environmentalists, and economists interested in cost-effective solutions to reduce global warming without compromising dairy farm sustainability. In France, the Eco-Methane organization brings together more than 600 farmers whose emissions reduction was estimated at 11% on average in 2017 (Bleu-Blanc-Coeur - BBC, 2022). Gloux et al., (2023), reported that BBC pays farmers according to their reduction of methane emissions in CO_2eq with a financial envelope made of donations from private actors (15€/tCO_2eq on average in 2017). The main strengths of the scheme lie in the strong scientific foundations of the method for quantifying emissions and the easy participation procedure for dairy farmers, (Gloux et al., 2023). Near-infrared spectroscopy (NIRS) from cattle feces could be used as a phenotyping method to predict dry matter intake (DMI) as well as enteric methane emissions (ECH_4), (Andueza et al., 2022).

Nutritional interventions to mitigate enteric CH_4 have been thoroughly investigated and, likely, strategies based on supplementation with plant extracts (such as a combination of Capsicum oleoresin and clove essential oils) may have a higher acceptance by livestock producers compared with, for example, the use of antibiotics, (Silvestre et al., 2022). Several secondary plant compounds including tannins and saponins have been evaluated for their potential to decrease CH_4 production from ruminants (Kozłowska et al., 2020; Jayanegara et al., 2012). Also, it is well known, that the addition of dietary fat can reduce methane emissions, (Olijhoek et al., 2022).

One of the proposed additives was essential oils (EO), classified as having an uncertain CH_4 mitigation potential with no long-term effects established (Hristov et al., 2013), and Hegarty et al., (2021) concluded in their review that there is medium evidence of the potential of EO to mitigate CH_4 in vivo. Despite the limitations, a positive and strong argument for continuing the research with EO to mitigate CH_4 emission in livestock is supported by the fact that these compounds may have a higher acceptance by consumers compared with, for example, synthetic CH_4 inhibitors, (Silvestre et al., 2023). Botanical preparations and EO are Generally Recognized as Safe (GRAS) compounds by the Food and Drug Administration (FDA; 2021). However, more research is needed to determine the long-term effects of EO supplementation, (Silvestre et al., 2023).

For a given productivity level, introducing fodder with high sources of omega 3 content such as grass or linseed in the feed ration of dairy cows both improves the milk nutritional profile and reduces enteric methane emissions per liter in France, (Gloux et al., 2023).

Many studies have compared feeding maize silage versus grass or grass-clover (starch vs. NDF) diets to dairy cattle, to study the effect on rumen digestion kinetics and CH4 emission, (Brask-Pedersen et al., 2023). The quality and the composition of silage is important element of ration on daily bases for ruminants feeding, (Ivetić 2017, Ivetić et al., 2018, Ivetić et al., 2013). It should be mentioned the application of alternative electron acceptors are organic (e.g., fumarate, malate) and inorganic (e.g., nitrate, sulfate) compounds that draw electrons away from methanogenesis and incorporate them into alternative pathways, (Beauchemin et al., 2022).

The ruminant gut structure fosters extensive enteric fermentation of their diet, (Ivetić, 2017). Enteric CH4 emission from ruminants not only exacerbates the global greenhouse effect but also reduces feed energy efficiency for the animals and Wang et al., (2023) explained that theoretically, redirecting [H] from methanogenesis to propionate formation to reduce CH_4 production could be a promising method for reducing greenhouse gas emission from ruminants, and may also increase animal productivity. Instead of directly inhibiting methanogenesis in the rumen, redirecting the flow of [H] towards alternative sinks could be a promising strategy. The complexity of the rumen poses challenges to reducing enteric CH_4 emission, but long-term comprehensive technologies may influence the evolution of the rumen and rebuild a microecosystem in a way that would favor the production of propionate to provide more sinks to dispose of H_2, (Wang et al., 2023).

Macroalgae (seaweeds) have highly variable chemical composition, depending upon species, time of collection, and growth environment, and they can contain bioactive components that inhibit methanogenesis, (Beauchemin et al., 2022). Seaweeds have been studied by Muizelaar et al., (2023) for their ability to reduce enteric methane emissions of ruminants when fed as a feed supplement. They reported that none of the seaweeds used in the experiment affected enteric gaseous emissions and that the inclusion rate might not have been sufficient for the specific metabolites in seaweeds to affect enteric methane production.

Methane inhibitors (3-NOP and bromochloromethane) had the largest CH_4 mitigation effect (Hristov et al., 2022) and did not affect DMI, fiber digestibility, milk production, or ADG. 3-Nitrooxypropanol is the most potent CH4 inhibitor currently available, exhibiting inhibition efficiencies of 20 % to 50 % across a range of doses, supplemental methods, diet compositions, and animal species, with no adverse impacts on diet digestion or animal performance (Hristov et al., 2015). Applied at 60 mg/kg feed DM via the TMR, 3-NOP decreased daily enteric CH4 emission by 26%, emission yield by 27%, and emission intensity (ECM basis) by 29%, (Melgar et al., 2021). Chemical inhibitors can be easily combined with other mitigation strategies and their adoption requires them to pass safety tests for animals, consumers, and the environment, (Beauchemin et al., 2022).

Two organizations based in the United States, the Foundation for Food and Agriculture Research and the Dairy Research Institute, have developed a collaborative program Greener Cattle Initiative to align resources and fund projects to identify, develop, and validate new and existing mitigation options for enteric methane emissions from dairy and beef cattle, (Tricarico et al., 2022), shown in Figure 1.

Increased confidence in mitigation estimates is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. The discovery of new enteric methane mitigation options, by itself, is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Mitigation options need to be deployed by a substantial number of dairy farmers to achieve the desired results, (Tricarico et al., 2022). For example, animal feed and health companies that develop enteric methane inhibitors currently need to pursue regulatory pathways that were developed to establish functional claims for drugs, such as compounds to cure, prevent, treat, or mitigate disease conditions or that change bodily structures or functions (United States Food and Drug Administration, 2022). Antimethanogenic strategies may decrease total CH_4 production (absolute emissions, g/d), CH_4yield (g/kg of DMI), or CH4 intensity (g/kg of meat, milk, or wool produced), (Beauchemin et al., 2022).

The number of monitoring tools and experiences is progressively increasing also due to improvements in the standardization of methods and the proliferation of research and accounting experiments, which bring about an increase in awareness of political subjects and the general public, (Marchi et al., 2023).

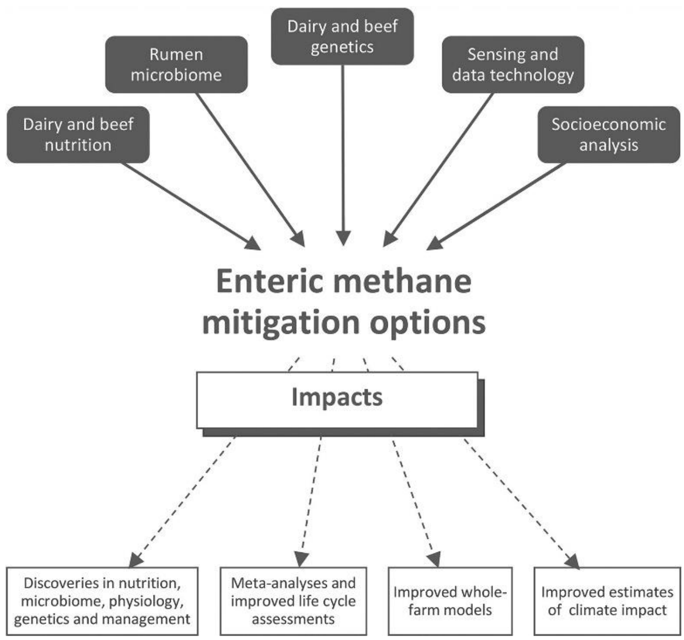

Figure 2. Areas of focus and expected impacts for research of enteric methane mitigation options for beef and dairy cattle, Tricarico et al., 2022

Conclusion

Air pollution depends on many natural and human factors. The agricultural sector is faced with challenges related to global warming and climate change, which affect human and animal food security. Increased confidence in mitigation estimation and practice is needed to develop socioeconomic innovation that encourages the adoption of mitigation options. The discovery of new enteric methane mitigation options, is not enough for the dairy sector to meet its environmental stewardship goals on climate change. Global challenges, such as enteric methane mitigation and its contribution to climate change, cannot be solved by one organization. Addressing these challenges requires collaboration among many organizations across different sectors, and is necessary to be followed by cross-border and worldwide cooperation.

Acknowledgment

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DETERMINATION OF COMPENSATION FOR DAMAGE AND LOST PROFIT DUE TO THE EXISTENCE OF A DIFFERENT RANGE OF PLUMS IN THE PLUMS

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Abstract

Buying seedlings at markets and from unauthorized sellers, without a certificate and quality guarantee, will initially be cheaper for the customer, but later the uneven quality of the planting material will cause additional costs, reduced income and ultimately loss and lost profit. Such cases of purchase often end in litigation, when the court hires licensed appraisers (experts) or commissions of experts, who will assess the resulting damage and lost profit, recommending the eventual clearing of such plantations. In this paper, one such case was analyzed, which ended in a court case and an expert opinion on damages and lost profits, due to the existence of a different assortment of plums in a plum tree. It is indisputable that the owner of a fruit plantation of different assortment and quality suffers damage, loses profit and realizes a loss, as evidenced by expert assessments, which are analyzed in this paper. In this case, considering that the plum tree is currently in the period of full bearing, the assessors do not suggest clearing the undesirable trees.

Key words: Different assortment of plums, damage, lost profit, possible grubbing, court experts.

Introduction

Plum production in Serbia has been a leading place for many years, and Serbia is at the very top of the world in plum production. The intensification of fresh plum production and the increase in the quality of plum products contribute to maintaining the current position and achieving even better results. Although there is a slight decrease in the number of trees, production is increasing on an annual basis, which is a consequence of the intensification of production. (Keserović et al., 2012) The export of prunes is below the possibilities and capacities at our disposal, it is variable and unorganized, and the market for the processing of plums into brandy is also characterized by spontaneous action, which results in changes in the assortment of this fruit. Dominant, autochthonous, rakija varieties are less and less represented, and the leading place in the structure of plum production is occupied by varieties such as Čačan's beauty, Stanley and Čačan's rodna, while Čačan's rana and Čačan's best are less present. (Nikolić et al., 2012)

In this paper, the authors analyze the damage and lost profit due to the variety of plums in the plum tree. The plum tree in question contains 6 varieties of plums, of which 3 varieties (Čačan's rana, Čačan's beauty and Čačan's best), domestic varieties, created at the Institute of Fruit Growing in Čačak, and are the result of domestic plum breeding, adapted to the agro-ecological conditions of a temperate-continental climate. (Institute for fruit growing Čačak). The Stanley and California Blue varieties were created in the USA, and the Grossa di Felicio variety is of Italian origin.

The economic efficiency of plum production is determined by numerous factors, of which the key ones are: choice of variety, location, application of Argo and technical measures, production costs and market prices. (Prodanović et al., 2017)

In the paper, the authors will show that due to the different assortment of plums in the plum orchard, the owner has increased costs, and at the same time he would be operating at a loss, which would not have been the case if only one variety of plums had been planted in the orchard. At the end, the question arises whether it is necessary and economically justified to cut down undesirable trees from orchards, to which the authors give and explain a negative answer.

These are the questions answered by evaluators from the economic, fruit growing and farming professions. How and why the seller sold plum seedlings without a certificate and guarantee, and why the buyer bought such seedlings, who is guilty and whether he is guilty, and who deceived and tricked whom, are questions that lawyers and judges should answer.

Material and methods

According to Article 154 and Article 155 of the Law on Obligations, "damage is the reduction of one's property (ordinary damage) and the prevention of its increase (lost benefit), as well as the infliction of physical or psychological pain or fear on another (immaterial damage). Whoever causes damage to another is obliged to compensate for it, unless he proves that the damage occurred without his fault".

It is a case of litigation between a buyer of plum seedlings and an unauthorized seller of the same, without a certificate or guarantee of quality. The purchase took place at the market, on the word and trust, that the object of purchase, that is, of sale, were plum seedlings of the Čačan's beauty variety. At the time of purchasing and taking over the seedlings, the buyer could not have known that the total amount of seedlings contained plum seedlings of other varieties, which he did not want to buy. Only after the planting of the plum seedlings and the passage of a period of 3 years, when the plum seedlings began to bear fruit, the buyer of the seedlings (the owner of the orchard) saw that different varieties of plums were planted in the plum tree. He initiated a court case, sued the unauthorized seller of seedlings and sought compensation for damages and lost profits. In this case, the court hired a commission of experts[1] (appraisers) to give an opinion on the circumstances of determining compensation for damages and lost profits in the

[1] The authors of this paper form the committee for expert opinion in the subject litigation

case of the plum tree in question. According to the Planting Material Act, the sale of planting material can be carried out by a company or an entrepreneur registered in the Register, and only basic, certified and standard planting material of varieties registered in the Register of Fruit Tree Varieties, Grapevines, Hops and substrate and which has a certificate for the production of planting material, with the fact that the sale of planting material can only be carried out at a point of sale that ensures the preservation of the properties of the planting material in terms of type, variety and category. (Law on planting material of fruit trees, vines and hops)

The assessors went to the field three times and interviewed the plantation owner. The first time - while the fruits were still green, the second time - during the ripening of most varieties in the plantation and the third time - after the end of the plum harvest. By going to the field, an inspection and analysis of the condition of the plantations was carried out on the spot, the number of trees, their development, structure of assortment, lushness, fertility and state of health were determined.

When giving an opinion and determining compensation for damage and lost profit, the following is taken into consideration:

1. Data from the Republic Geodetic Institute (RGZ), eCadastre - real estate cadastre database in the Republic of Serbia (https://katastar.rgz.gov.rs/eKatastarPublic)
2. Data from the NIGP Digital Platform (https://a3.geosrbija.rs/)
3. Interview with the owner of the orchard
4. Data on the purpose of the land in question
5. The functional significance that it currently has for the owner
6. Fruit crops grown on the plot and possibilities for growing other crops on the plot in question
7. Water-air and physical properties of the soil, which were determined on the basis of field insight into the mechanical composition.

Based on all these parameters, an analysis of the production and economic possibilities of the agricultural production realized so far was carried out. A calculative method is used to determine profit, loss and damage.

A licensed appraiser, depending on the available data, should choose the most appropriate valuation technique, and the valuation is done with the application of relevant market data. The assessment of the value (damage) of lost profits includes a market approach, a yield approach and a cost approach, with a comparative (comparative) analysis of income and costs, and with the application of the principles of independence and autonomy, the principles of integrity, the principles of responsibility and the prohibition of causing damage, as well as the principles of transparency. (Regulation on national standards, code of ethics and rules of professional conduct of a licensed appraiser)

Table 1. Basic characteristics of different plum varieties in the subject plum tree

Plum varieties	Picking time	Fruit weight	Characteristics
Čačan's beauty	End of July and beginning of August	30-40 gr.	The stone is easily separated from the flesh of the fruit. The fruits are very firm and withstand transport after harvest.
Stanley	End of August	38 gr.	The fruits tolerate transport well after picking, the variety has good resistance to hinge.
California Blue	End of July	40-50 gr.	The fruits are round, purple-blue in color and larger in size. There is a wax coating on the skin. Good as a table fruit, it tolerates transport well.
Čačan's best	Second half of August	44 gr. Max 90-100 gr.	It has large fruits, the hive is easily separated from the flesh of the fruit. It tolerates transport very well after harvest.
Čačan's rana	End of June and beginning of July	36-40 gr. max 80gr.	At full maturity, it cannot be stored for long. Transportability is good, although ripe fruits are less able to tolerate transport.
Grossa di Felicio	Second half of August	60 gr.	It is mostly used as a table variety, but also for brandy. The bone separates nicely from the meat.

Source: Authors, according to https://www.institut-cacak.org/sorte.html; http://wiki.poljoininfo.com/

From table 1 we can see that the varieties of plums planted in the orchard in question have different ripening and picking times, different size and weight of fruits, transport after harvesting differently, have different resistance to diseases, which requires the application of different agrotechnical measures. All this affects the level of production costs. Incomes are determined by yields per tree and market prices per kilogram of fresh fruit, which are also different, which is shown in table 2. The only thing that is the same for all analyzed plum varieties are the years of full bearing and for all included plum varieties, they are 15 years.

Results and Discussion

Location, quality and appearance of plots (micro and macro)

Cadastral parcels number 2754/2, 2757/1 and 2757/2, which form a whole on the ground, have a total area of 50 ares (5000 m2) and are located in the Cadastral Municipality of Donja Omašnica (Figure 1). In the vicinity of these plots, there are other plots on which there are also vegetable plants. The surface on which the plums are planted has a slight slope. The parcels in question can be accessed by the Polish roads located between them, and there are no other infrastructure facilities (water, electricity, sewerage, storage space...) on them. The land has a flat relief and is located at about 200m above sea level, with a loamy mechanical composition, crumbly structure, good permeability, good physical properties and a favorable water-air regime. It is suitable for processing and organizing fruit and viticulture production.

Figure 1. Location of plots 2757/1, 2757/2 and 2754/2 in KO Omašnica

Source: https://a3.geosrbija.rs/katastar; https://katastar.rgz.gov.rs/eKatastarPublic (date of access 06/05/2023)

Perennial plantings on the plot in question

The parcels in question are registered as agricultural land, 4th class vineyard, in the eCadastre of Real Estate of the RGZ of the Republic of Serbia and are privately owned by a natural person.

Going out to the field, it was established that there are perennial plant plantations (plum plantations) on the plots in question. So far, it is in the period of full fertility. So far, in 2022, it has been properly maintained (protection, processing, etc.). However, it can be seen that so far in the previous years it did not continuously have adequate protection, which is indicated by phenomena on the tree (cracked bark, appearance of resin, black or dry twigs of monilia, etc.) Analysis of the condition in the field found that there are several varieties in planting. The dominant variety in the plantation is Čačan's beauty. In addition to it, there are other varieties mixed in the plantation (Stanley, California blue, Čačan's best, Čačan's rana and Grossa di felicio). The plum fruit varieties are in different phenophases, and there are 14 rows in the orchard.

Since it is currently in the period of full fertility, it is not possible to reliably determine when the trees were planted by going out into the field. Also, in this period, it is difficult to determine the differences in the age of the trees, although in the last four rows (closer to the approach to the plot, the field road and the settlement) the trees are a shade less lush (they have thinner trunks). Table 2 shows the circumference of the trunk at 20 cm above the ground in the varieties Čačan's beauty and Stanley. The trunk circumference of the other varieties did not make sense to measure because there was an insufficient number of varieties to draw a conclusion.

Table 2. Trunk volume of plum varieties (average)

Plum varieties	Trunk volume (cm)	
	I-X row	XI-XIV row
Čačan's beauty	28,2	24,1
Stanley	32,1	27,2

Sources: Authors, based on the situation on the ground

From Table 2, it can be concluded that the circumference of the trunk in the last four rows is slightly smaller compared to the other rows (I-X). This may be a consequence of later planting, but also of poor soil quality and poor care on this part of the surface. In the last four rows, a total of 85 healthy trees and one dry tree were found. Out of that number, 75 trees had a slightly lower luxuriance.

Analysis of damage and lost profit due to the variety of plum varieties in the plum orchard

Due to the existence of several varieties of plums in a plum orchard, individual phenophases occur differently. The different passage through some phenophases (flowering, harvesting, etc.) requires the performance of agrotechnical operations in different periods, which makes it difficult to protect and harvest the fruits.

After Čačan's beauty, the Stanley variety is in second place in terms of representation in the plantation. She requires two additional treatments compared to the Čačan's Beauty. Also, harvesting must be done at different times, which complicates the organization of the harvest itself.

The damage is also reflected in the different prices of the fruits.

Due to the existence of a different assortment of plums in the plum tree, the owner of the plum tree suffers a loss of profit. That damage is reflected in increased costs when it comes to protection. Also, harvesting is more expensive because it is done at different times. The purchase price of the Čačan's beauty variety is slightly higher compared to the Stanley variety, but the Stanley variety is more productive than the Čačan's beauty variety. The number of other varieties of plums in the plum orchard is significantly smaller, so their participation in damage and lost profit is significantly smaller. The calculation of growing varieties is shown in tables 3 and 4.

Table 3. Calculation of the cultivation of the plum variety Čačan's beauty and other varieties in the plum tree

Plum varieties	Čačan's beauty	Stanley	Californian blue	Čačan's best	Čačan's rana	Grossa di felicio
Yield per tree (kg)	30	40	25	30	20	40
Price per kg (in RSD)	40	25	40	40	50	40
Gross income per tree (in RSD)	1.200	1.000	1.000	1.200	1.000	1.600
Number of trees	64	44	9	6	3	2
Gross Income	76.800	44.000	9.000	7.200	3.000	3.200
Years full of fertility	15	15	15	15	15	15
Gross income (in RSD)	1.152.000	660.000	135.000	108.000	45.000	48.000
Production costs and sales (in RSD)[2]	403.200	277.200	56.700	45.360	18.900	20.160
Net income (in RSD)	748.800	382.800	78.300	62.640	26.100	27.840

Source: Authors, based on average yields and market prices for 2022.

Table 3 shows the differences in income between the cultivation of the Čačan's beauty variety and other varieties. We can see that the number of trees of the Čačan's beauty variety is the same as the sum of the trees of all other plum varieties in the plum tree. If the owner of the plantation decided to harvest the fruits from all the trees, the losses due to the existence of other varieties in the plantation would amount to 171,120 RSD (table 4).

Table 4. Loss due to the presence of different varieties of plums

Varieties of plums	Net income (in RSD)
Čačan's blue	748.800
Other varieties	577.680
Loss of income	**171.120**

Source: Authors

The Stanley and Grossa di Felicio varieties are harvested at approximately the same time. If at the location in question there were interested parties to harvest and buy plums on the tree, of the Stanley (44 trees) and Grossa di Felicio (2 trees) varieties, which is a total of 46 trees at a price of 15 din/kg, the production and sales costs would be twice as low, and the potential profit for these two varieties would amount to 331,200 dinars (Table 5). Based on that, the loss due to missed benefits in that option would amount to 417,600 RSD (Table 6).

[2] For other varieties, additional costs of protection and harvesting are included.

Table 5. Calculation of cultivation of Stanley and Grossa di Felicio varieties different varieties when the buyer picks when the buyer picks the fruits fruits of the Stanley and Grossa di Felicio varieties

Plum varieties /Indicator	Stenley	Grossa di felicio
Yield per tree (kg)	40	40
Price per kg (in RSD)	15	15
Gross revenue per tree (in RSD)	600	600
Number of trees	44	2
Gross Income	26.400	1.200
Full years gender	15	15
Gross Income (in RSD)	396.000	18.000
Costs production and sales (in RSD)[3]	79.200	3.600
Net income (in RSD)	**316.800**	**14.400**
Total	**331.200**	

Table 6. Loss due to the existence of Stanley and Grossa di Felicio varieties different varieties when the buyer picks when the buyer picks the fruits fruits of the Stanley and Grossa di Felicio varieties

Plum varieties /Indicator	Neto prihod (u din.)
Čačan's beauty	748.800
Net income of the Stanley and Grossa di Felicio varieties	331.200
Loss of income	**417.600**

Source: Authors, based on average yields and market prices for 2022.

The authors of this paper believe that the clearing of undesirable trees is not necessary, considering that it is currently in the period of full fertility and should give maximum yields, with the implementation of adequate agro-technical measures. Clearing does not make sense yet, because the trees are mixed in the plantation. In addition, when there are more varieties in the plantation, fertilization is more efficient and the yields are somewhat higher. If trees of other varieties were removed and new seedlings of the Čačan's beauty variety were planted in their place, those planted trees would never be able to develop, because they are shaded by neighboring trees. Their growth would be stunted and I would never be able to produce full yields.

Conclusion

On the cadastral parcels number 2754/2, 2757/1 and 2757/2, which form a whole on the ground and have a total area of 50 ares (5000 m2) in the KO Donja Omašnica, on which there are plums, it was determined that the plums are of different assortment (Čačan's beauty, California blue, Stanley, Čačan's best and Čačan's rana). The owner of the orchard, and as it is a case of litigation, at the

[3] Isto.

same time the plaintiff, suffers damage due to the existence of different assortments in the orchard, which is reflected in the organizational and financial aspect, additional protection and lower net income than if only the Čačan's beauty variety was found, which he wanted to buy and plant on the plots in question. At this age of the plum seedlings, it is not recommended to clear unwanted trees. What is extremely important, and in this case proved harmful and economically disadvantageous, fruit growers should be encouraged to use certified seedlings. Certified seedlings are of better quality and are a prerequisite for achieving higher yields. The number of required herbicide treatments is reduced while reducing costs. Certified planting material is a prerequisite for farmers who want to achieve higher yields, and therefore higher profits.

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REMAINS OF DECORATIVE PLANTS AND THE FUNCTION OF PROTECTION OF THE ENVIRONMENT AND HEALTH

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Abstract

The herbal drugs prepared with the traditional methods through slow grinding and mixing processes conserves all the natural substances without losing any essential component, maintains the activity and purity of the drug, and have potential medicinal uses. Use of plants as herbal cosmetics is known since ancient times. In this study, the remains of herbaceous and woody biomass decorative plants were analyzed because a large number of herbaceous, both annual and perennial species of decorative plants contain substances that are important raw materials for cosmetic and pharmaceutical preparations. Smaller amounts of herbaceous biomass are used for compost production. The wood biomass of decorative plants can be used as solid fuel or cut, and the obtained boards and laths are used for making various objects. Fruits (seeds), flowers, leaves, stems and roots of decorative plants were also analyzed. Certain plant organs such as boxwood, linden and birch leaves are used for medicinal purposes. These plants can be grown on decorative surfaces in gardens for their own needs and prepared to prepare teas and other medicinal drinks that are used as means to improve the health of people, but also domestic animals and pets. As decorative plants are valued, among others, the Oman, which blooms for a long time forming beautiful yellow inflorescences that are also used as cut flowers.

Key words: Maize hybrids, quality, green biomass.

Introduction

Decorative plants can be annual and perennial herbaceous plants, as well as perennial shrubby and woody plants, which with their flowers, leaves or habit beautify public areas such as parks, promenades and sports fields, then yards, interiors of residential and work buildings (potted species). They can also be grown on arable land, and these are species that are grown for cut flowers and for the purpose of producing seeds or planting material. Some of the decorative plants are sometimes used in the pharmaceutical, cosmetic and food industries. However, the most important role of these plants is visual effects. From an economic point of view, these plants in urban areas reduce the cost of energy needed for heating or cooling, increase the value of residential buildings, while public areas (parks and recreation centers) become more interesting for tourists. From an ecological point of view, with their above-ground biomass, they influence climatic extremes by mitigating the consequences of all forms of erosion, then consume carbon dioxide releasing oxygen, reduce city noise, have a positive effect on people's health and well-being, and the like. In order for these plants to exhibit the mentioned positive effects, it is necessary to apply numerous care measures throughout the year. One of the important care measures is regular pruning in order to form the desired shape of the habitus of woody plants. In the case of annual herbaceous species, the care measure is the removal of over flowered, damaged and dried above-ground organs of trees and leaves, then mowing of decorative grass areas and the like. After these care measures, large amounts of fresh biomass remain, which can be used in several ways in order to obtain useful products from organic waste for further use. They are grown as decorative on agricultural and non-agricultural (parks, areas around residential buildings, factories, around roads, etc.) surfaces and medicinal, which can be cultivated and wild. Most of these species can be used as ornamental or medicinal plants, and some for-food purposes (Glamočlija et al., 2015; Janković et al., 2019). Some decorative plants are also medicinal, in their vegetative or generative organs they synthesize medicinal substances that have a beneficial effect on the health of people and domestic animals. In treatment, they are used as auxiliary medicinals of folk (alternative) medicine, and according to data from the World Health Organization (WHO), about 80% of the world's population uses medicinal products based on medicinal plants. The maintenance of large decorative surfaces is performed by specialized services equipped with the necessary machinery and places for disposal and biodegradation of collected residues. Further processing of plant residues depends on the type (herbaceous or woody) and the amount of biomass in order to protect the environment. In this study, the remains of decorative plants of herbaceous and woody biomass were analyzed because a large number of decorative plants contain substances that are important raw materials for cosmetic and pharmaceutical preparations (Glamočlija et al., 2015; Burić et al., 2023; Stevanović et al., 2023).

Material and methods

In this study, the remains of decorative herbaceous and woody plants were analyzed because a large number of herbaceous annual and perennial species contain substances that are important raw materials for cosmetic and pharmaceutical preparations. Smaller amounts of herbaceous biomass are used for compost production. The biomass of decorative plants can be used as solid fuel or can be cut, and the obtained boards and laths are used to make various objects, for example park benches, various decorative baskets, household appliances and the like. Fruits (seeds), flowers, leaves, stems and roots of decorative plants, which are used in pharmaceutical and other industrial branches, were also analyzed. Certain plant organs such as boxwood, linden and birch leaves are used for medicinal purposes.

Results and Discussion

Further use of plant residues

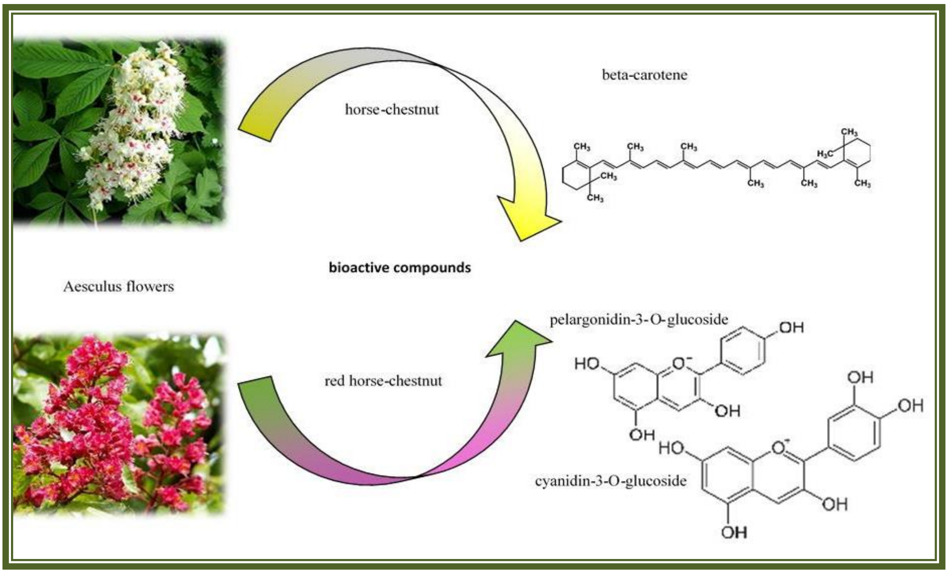
Herbaceous biomass is used to produce compost which serves as a substrate for the preparation of humus soil for filling pots or is sold to flower growers. The biomass of decorative plants can be used as a solid fuel or can be cut, and obtaining planks and laths that are used to make various items, for example park benches, various decorative baskets, household appliances and the like. Chopped biomass is suitable for mixing with herbaceous biomass (grass leaf, clippings, leaves, etc.) to make compost.

If the quantities of fresh biomass are large enough that they cannot be used in the described way, they can be used as raw material for obtaining biogas, and the residues after the process should be taken to the land areas that are in the process of remediation.

Use of fruits (seeds), flowers, leaves, stems and roots of decorative plants

A greater number of woody species of ornamental plants form fruits during the year that can be used in the cosmetic and pharmaceutical industry if they are healthy and uncontaminated by aerosols. Acorns, leaves and oak twigs contain significant amounts of chemical substances that are used in pharmaceutical and other industries (Popović et al., 2018, 2021).

***Aesculus hippocastanum* (L.) -** Park chestnut or wild chestnut is a deciduous tree native to a small area on the Pindus and Balkan Mountains, where it grows in mixed forests, but as a park species it can be found throughout Europe and North America. It develops a tall tree up to 30 m with a wide dense crown of 15 to 20 m. It blooms in spring (in our conditions in May) in upright panicles 10–30 cm high with about 20–50 flowers in each inflorescence. Usually only 1–5 fruits develop on each panicle. The fruit contains one (rarely two) large brown and shiny seeds encased in a green spiny husk that bursts when the seeds ripen, in September. Horse chestnut fruits are inedible (mildly poisonous), but widely used in folk medicine. Park chestnut in bark, leaves, flowers and seeds has 40-60% starch, 5-8% saponin, 5-8% oil, proteins, glycosides, tannins, resin, vitamins (B, C, K and P), beta-carotene (Picture 1) then alkaloids escin, quercetin and other compounds used in the pharmaceutical industry. Medicines produced on the basis of chestnut alkaloids are used for the treatment of vascular diseases and in veterinary medicine (Pittenger et al., 2002).



Picture 1. Bioactive components in *Aesculus* flowers (Bielarska et al., 2022)

Certain plant organs and other decorative plants are used for medicinal purposes, for example: boxwood leaves against gout, rheumatism, fever; viburnum leaves and fruits for stomach ailments; from linden liquina fibers, timber, flowers for teas and it is an important honey plant; from birch wood for carving, sap as a drink, nutritious leaf buds, flour from the inner bark, teas and baths from dry leaves, and so on.

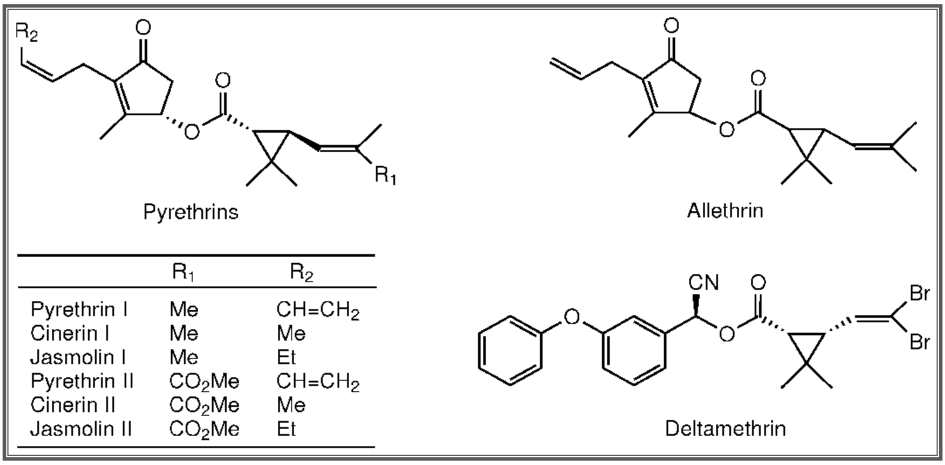
Certain plant organs of herbaceous decorative species can also serve as an important raw material in the pharmaceutical and cosmetic industry. Sharma and Kumar (2013) emphasize that a large number of herbaceous, annual and perennial species of decorative plants contain substances that are important raw materials for cosmetic and pharmaceutical preparations. The plants used in cosmetics donot merely enhance beauty but have definite medicinal value also. Sandal (*Santalum album* Linn.), turmeric (*Curcuma domestica* Valeton.) and other plants are used in the formation of a paste for improving the complexion of a bride. Women use sandal (*Santalum album* Linn.), rose (*Rosa damascene* Mill.) to perfume their body. *Acacia concinna* DC. (Vern.Shikakai); Pods are blended into shampoo and hair cleanser with *Sapindus mukorossi* Gaertn Vern. Ritha to promote hair growth and to stop hairsplitting, falling and dandruff.

These plants can be grown on decorative surfaces for preparing teas and other medicinal drinks that are used as means to improve the health of people, but also domestic animals and pets. As decorative plants are valued, among others, the oman, which blooms for a long time forming beautiful yellow inflorescences that are also used as cut flowers.

The roots of this plant are very medicinal and were used in ancient times to make medicines against cough and bronchitis. The roots of some other plants have a similar medicinal value, and in recent times, they are also grown more and more on flower beds. Such is the type of echinacea whose roots are used in folk and official medicine.

From the rose family, a perennial herbaceous species of *Filipendula ulmaria* L. / *Spirea ulmaria* L.) (suručica in Serbian) is grown as a decorative plant. The plant is valued as edible and medicinal because it contains salicylic compounds. It is used in folk medicine for the preparation of analgesic drugs.

***Pyrethrum cinerariaefolium* Vis. -** (Buhač in Serbian) one of the most powerful natural insecticides. *Pyrethrum cinerariaefolium* thrives well on sandy and stony surfaces and can be grown for decorative purposes on such terrains. It is a perennial bushy plant that blooms all year round, forming yellow head-shaped inflorescences. The plant has been used for medicinal purposes since ancient times.



Picture 2. Chemical structures of the neurotoxic insecticides Pyrethrins (Kojima et al., 2022)

Today's pharmacopoeia treats the feverfew herb as a remedy against fever and colds, but one should be careful because the plant is poisonous, due to pyrethrins, Picture 2. In the past decades, in addition to the decorative value it has in specific parts of the gardens, in some countries, the wild rose is grown on larger areas and serves as a raw material for the production of bioinsecticides (Casida, 1973; 1980; Amason et al., 1989; Cox, 2002; Grdiša & Gršić, 2013).

Pyrethrins are completely safe, there are some exceptions. Pyrethrins do not accumulate in muscle, fat or other human tissues. The toxic effect of pyrethrins is greater in children and the elderly, who are more sensitive. Symptoms that may occur in some people who frequently use pyrethrin indoors are hypersensitivity pneumonitis, inflammation of the lung tissues, cough and shortness of breath. In contact with the skin, pyrethrin can cause moderate skin irritation, and mild irritation in contact with the eyes. and to nausea, vomiting, diarrhea and abdominal pain (Macan et al., 2006). The most common symptoms that appear on the skin are various forms of dermatitis, swelling of the face, itching, scaling, cracking, burning and sensitivity of the skin, weight loss, various edemas and erythemas (www.atsdr.cdc.gov). Most symptoms disappear very quickly (Casida, 1973).

Treatment of closed rooms can cause pyrethrin to linger in certain parts of the room, where it can remain in its original form for up to 75 days (Cox, 2002). Macan et al. (2006) state that glycoproteins, glycopeptides and sesquiterpene lactones (the most important pyrethrosine) that cause allergic reactions were identified in the unrefined extract of the flea beetle. McCord et al. (1921) mention the appearance of a skin disease called erythema venenstum that appeared on the skin of the face and forearms in the form of lesions. The pyrethrin used today is mostly purified from impurities, does not contain impurities, and does not cause severe allergies that occurred in the past (Casida, 1980, Grdiša and Gršić, 2013). If an allergy does occur, there is a high probability that it will pass quickly. The most common cause of asthma as a result of using pyrethrins are the impurities found in the mixture.

Pyrethrins are used to control a wide range of insects, some of which are: plant bugs, cicadas, cabbage white caterpillars, most aphids, pips, bloody apple aphids, small and chestnut mealybugs, red fruit spider, bird mites, cherry wasp larvae, crickets, thrips, moths, ticks, fleas, mosquitoes, cockroaches, flies, wasps, hornets, wasps, some types of lepidoptera, etc. (Arnason et al., 1989; Casida, 1973, Casida, 1980; Kovačić et al., 2008; Pejić, 2019; www.infonet-biovision.org).

Galium verum **L**. (Ivanjsko cveće in Serbian), midsummer flowers are recognizable by their golden-yellow flowers whose smell is reminiscent of honey, this medicinal plant is widely distributed in our area. It grows in meadows and roadsides, mostly in dry and sunny habitats, and blooms throughout the summer.

Due to beneficial effects of *Galium* species noticed over time, there are now galenic remedies and dietary supplements considered to help in several health disorders, mainly involving immune system, anti-inflammatory processes, detoxication and oxidative stress, Pictures 3 and 4.

Midsummer flowers are a favorite decorative plant that has been cultivated since ancient times. In addition to the basic role of beautifying the space in decorative gardens and in the backyards, this decorative plant is used in folk medicine Shahmoradi et al., (2016). Inflorescences containing medicinal substances, essential oils, rutin, cinnaroside, flavonoids and salts of organic acids serve as drugs.

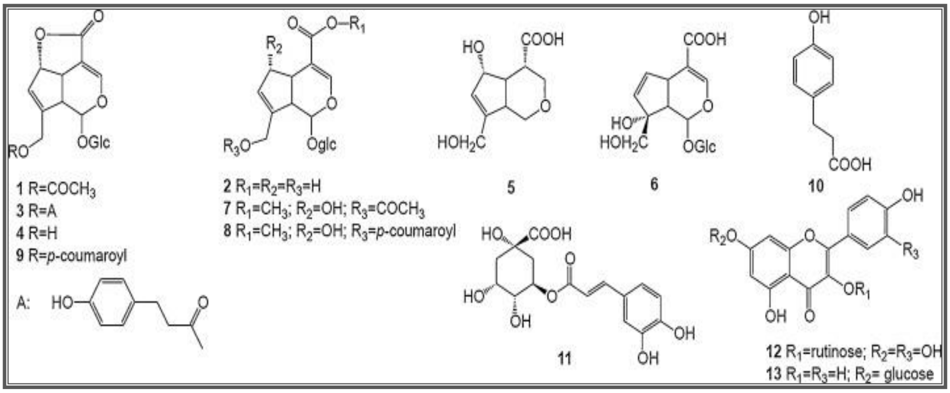
The reported biological activities of *Gallium verum* are presented in Table 1.

Table 1. Biological activities of *Gallium verum*

Use	Pathology	Biological activity
Internal use	Urinary stone complaints, Scurvy, Dropsy, Hysterics, Epilepsy, Gout, Nose bleeding, Stomach problems, Diarrhea, Scorbutic, scrofulous anddropsically complaints, Antistress—immuno modulatory, Pyelitis, Cystitis, Liver disorders, Cardiovascular diseases, Thyroidian, ovarian, adrenal and gluco corticoidhormones synthesis stimulation (in vitro).	Antioxidant (investigated and proved by DPPH, ABTS in vitro assays), Cytotoxic (investigated and proven in high doses in neck cancer cell linesHLaC78 and FADU: cell motility and invasion strong inhibition, DNA protection against benzo[a]pyrene's toxicity in cigarettes), Protective: hepatic-protector, thymus protector,Antimicrobial (antibacterial and antifungal activity) (water, alcohol,chloroform extract): Staphylococcus aureus, Escherichia coli, Pseudomonasaeruginosa, Bacillus subtilis, Proteus vulgaris, Candida albicans, Endocrine system: morphological changes of hypothalamus-hypophysis-adrenal axis resulting in enhanced of neurosecretory activity
External use	Indolent tumors, Strumous swelling and tumors of breast, Psoriasis, Delayed wound healing, Cancerous ulcer, Breast cancer, Bacterial and fungal infections, Parasitoses, Gingival inflammation, Cosmetic purposes	Antihaemolytic activity, Cholinesterase activation, Non-specific defense mechanism Detoxicant, Antibacterial, antifungal against Gram-positive microorganisms (S. aureus, L. monocytogenes) Anticandidiasis effect (on Candida albicans, C. tropicalis, C. glabrata)

Source: Turcov et al., 2022

Preparations of St. John's wort are used to treat kidney diseases, inflammation of the liver, as well as psychological disorders (anxiety, hysteria, epilepsy and others). In the production of dairy products, it is added to curdle milk and color cheese. Midsummer flowers are an exotic, entomophilous species and belong to the group of honey plants.



Picture 3. Chemical structures of the *Galium sp.*

Achillea millefolium L. is characterized by broad ground leaves arranged in the form of a rosette and an upright stem up to 80 cm long, on which small pinnate leaves are arranged on short stalks, at the top of which there is a rich inflorescence made of small white or light pink flowers. St. John's wort belongs to the *Asteraceae* plant family, and has many therapeutic uses.

Achillea millefolium L. (Yarrow), belongs to *Asteraceae* family and it is represented by about 85 species mostly found in Europe and Asia and a handful in North America. In the folk medicine yarrow is used for treatment of fever, asthma, bronchitis, cough, skin inflammation, jaundice, diabetes, hepatobiliary diseases, healing of wounds, menstrual regulation, flatulence, dyspepsia, hemorrhoids, dysmenorrhoea and gastritis and also consumed for its antitumour, antimicrobial, anti-inflammatory and antioxidant properties. Antioxidant properties of *A. millefolium* have previously been reported in hydroalcoholic, methanolic and aqueous extracts, as also in the essential oils (Candan et al., 2010; Trumbeckaite et al., 2011; Vitalini et al., 2011). Hyperoside was the flavonoid compound present at high concentrations among the investigated standards (604.95 and 453.25 μg/g dw, respectively), Table 2.

Table 2. Flavonoid aglycones and glycosides content in extract from *Achillea millefolium*, μg/g dw

Flavonoids aglycines and glycosides / extract	Microwave extr.	Decoction extr.
Myrcetin	52.00	45.44
Luteolin	95.21	126.97
Kaempherol	15.91	126.97
Rutin	54.03	94.80
Hyperoside	453.25	604.95

Source: Georgieva et al., 2015

a. b. c. d.

Picture 4. Park chestnut, a, flea, b, midsummer flowers, c., Yarrow, d.

Yarrow is an often cultivated, but also widespread self-flowering flower species with a perennial life cycle. In addition to its decorative value, this plant has always played an important role in folk medicine. The above-ground organs of plants (flowers and trees with leaves), which have a strong antibacterial effect, are used as drugs. Preparations made from the drug yarrow are used in official medicine for the treatment of diseases of the stomach and intestines, as well as against hepatitis, high blood pressure and as a means of preventing thrombosis. In folk (alternative) medicine, the leaves are used to stop bleeding, then in the treatment of injuries, purulent wounds and in soothing skin inflammations. Some nations use it in cooking. Flowers and leaves are used for the preparation of dishes to which they give a specific aroma, and in the production of alcoholic beverages for the preparation of liqueur. It is also highly valued as a honey plant.

Conclusion

Herbaceous biomass is used to produce compost. The wood biomass of decorative plants can be used as solid fuel or cut, and the obtained boards and laths are used for making various objects. A greater number of woody species of ornamental plants form fruits during the year that can be used in the cosmetic and pharmaceutical industry if they are healthy and uncontaminated by aerosols. In addition to the basic role of decorative plants to beautify the space in decorative gardens and on the homesteads, decorative plants are used in folk medicine because in their vegetative or generative organs they synthesize medicinal substances that have a beneficial effect on the health of people and domestic animals. In treatment, they are used as auxiliary medicinal of folk (alternative) medicine, and according to data from the World Health Organization (WHO), about 80% of the world's population uses medicinal products based on medicinal plants.

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application on maize productivity of different FAO maturity group using classical and modern technology.

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INFLUENCE OF DIGESTATE ON THE PRODUCTIVITY OF OATS IN DIFFERENT ENVIRONMENTAL CONDITIONS

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Abstract

Thanks to the grain's high energy and nutritional value, oats are of great economic importance. The paper analyzed the productivity of oats on fertile soil, chernozem in a two-year period and in two variants of feeding: control (variants without feeding) and in the variant with digestate. Oat productivity parameters were analyzed: number of ears per panicle, grain mass per panicle and compared with grain yield per hectare. The results showed that year and digestate had a statistically significant effect on the number of spikelets per panicle of oats and that higher values of grain weight per panicle were achieved in the digestate variant compared to the control variant. The digestate had a significant effect on the increase in oat productivity parameters and its application in the oat crop is justified.

Key words: Oats, seed storage, production year, digestate, productivity parameters.

Introduction

Oats (*Avena sativa* L.) is a true cereal that has a smaller area of distribution due to less tolerance to frost and drought. Thanks to the grain's high energy and nutritional value, oats are of great economic importance. Hulled grain is used in human nutrition and unhulled grain and above-ground biomass as food for domestic and farmed animals. Oats are known as natural functional food. Oats for human consumption are responsible for numerous health benefits in addition to basic nutrition (Burić et al., 2023). In human nutrition, peeled oat grain is used in the form of oatmeal, semolina and oat flour, which is mixed with wheat flour to make bread and other bakery - bread products (Figure 1a-c). In the diet of domestic animals, oats can be used in two basic ways, as concentrated and voluminouse fodder. Oat grain has 8.18% digestible proteins, has higher nutritional value than corn and 1.02 nutritional units (Glamočlija et al., 2015; Lakić et al., 2018; Rajičić & Terzić, 2021; Burić et al., 2022). In our country, it is grown more as a fodder plant in mixtures with buttercups, and less for grain. If it is grown for grain, the unpeeled fruits are used as animal feed, and the peeled fruits are used for the industrial preparation of finished food products of high nutritional value. Secondary products are harvest residues (whose percentage share in the total biomass yield is higher than in other grains), followed by chaff, poorly grains and bran that remain after grain milling.

Despite its great economic importance and diverse application in nutrition and industrial processing, the area sown under oats in some countries, which were the largest producers, decreased, but increased in South America and some European countries, especially where the grain is increasingly used in feed people. The trend of decreasing areas in the last decades of the last century was greatly influenced by the weak competitiveness of oats with other more productive types of grain and a significant decrease in the number of horses for which oat grain served as the main concentrated feed.

For most types of soil in Serbia conditions, to achieve high yield and good grain quality, on average, should be applied 60-90 kg ha^{-1} of N, 60-90 kg ha^{-1} of P_2O_5 and 40-60 kg ha^{-1} of K_2O pure nutrients. Phosphorus and potassium fertilizers are introduced in winter oats 50% in the basic tillage and 50% before sowing, while in spring oats all phosphorus and potassium quantities are introduced in autumn under basic tillage. In more humid regions, the amount of nitrogen for fertilization is added early in the spring during intense tillering (the first fertilization with half of the anticipated amount) and the second fertilization at the beginning of stem elongation with the remaining amount of nitrogen. In the case of spring oats in arid regions, the entire amount of nitrogen is given before basic treatment or pre-sowing preparation, i.e., without top dressing (Rajičić et al., 2020; 2021). The aim of this study was to investigate the effect of digestate on oat productivity on chernozem.

Materials and methods

In this study, the analysis of oat production in the world (FAO 2023) as well as the influence of digestate on oat productivity on black soil was monitored. The experiments were carried out in Kovin, Pančevo municipality during 2021 and 2022, on chernozem type soil in three repetitions. The elementary plot was 25m2. Sejana is a spring oat variety of NS Dunav. Precrop was soybeans. Soil cultivation was carried out according to standard methods for spring crops. Instead of fertilization, digestate was applied as a nutrient and a control variant was without digestate. The entire amount of digestate was given in the pre-sowing preparation. Sowing was done in mid-February, Harvesting was done in early August with a harvester for experiment. The following parameters were analyzed: Number of spikelets per panicle of oats and mass (yield) of grain per panicle (g). The yield was measured on the day of harvest and converted to 14% moisture.

The economic importance of oats is reflected in the quality of its grain, from which high-quality products are obtained, Figure 1a-c. Oats are harvested at technological maturity, Figure 1a. Oat seed is dried to 14-15% moisture, Figure 1b, and stored in storage silos, Figure 2.

a) b) c)

Figure 1. Oat crop (a), oat seed (b) and oat products (c)

Seed storage

Seed storage is the final work operation in the oat production process. There are several types of storage: normal storage, storage with drying or additional drying of products and storage with preservation of products. When storing oats, the most important condition during storage is maintaining humidity at optimal values. Oat grain with a higher percentage of water after harvesting is dried in dryers or directly poured into a silo that has an innovative mixing propeller that works with the help of SMART-THINGS, i.e. with the help of sensors as shown in Figure 2.

The sensors are monitoring the humidity of the oat grain, reporting to the central sensor that automatically blows moist or dry air directly with the help of the unit, depending on the need, in order to maintain optimal conditions for storing oat seeds.

a) b)

Figure 2. Silos for storing oats, Designed by (a) Ristić & Popović, 2023 (b)

Meteorological Conditions

During the investigation, meteorological data, temperature and precipitation were very variable. Crop production is highly sensitive to climate, which means that climate change significantly affects crop production (Popović et al., 2011; 2020a; 2020b; 2022). The meteorological conditions, monthly precipitation and air temperatures for 2021 and 2022 during the trial were taken from the Hydro-meteorological service of the Republic of Serbia, situated in Pančevo (Table 1).

Table 1. Average monthly temperatures and amounts of precipitation for the oat vegetation period during 2021 and 2022 in Pančevo

Parameter	**Temperature (°C)**						
Month	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**Average**
2021	13,2	16.04	21.60	25.30	22.00	17.00	19.25
2022	9.89	17.14	21.70	25.28	22.04	17.87	19.03
Parameter	**Precipitation (mm)**						
Month	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**Total**
2021	44.0	73.3	31.1	110	48.3	21.7	328.4
2022	54.6	63.1	41.7	142	38.3	11.7	351.4

Average temperatures in the growing season in 2021 were 19.25 °C and were higher by 0.22 °C compared to the growing season of 2022, while total precipitation in 2022 was higher by 23 mm, but with an unfavorable schedule, especially in critical stages for oats. Precipitation and temperature have a decisive influence on the yield (Ljubičić et al., 2021; 2023; Milunović et al., 2022).

Results and Discussion

Oat production in the world

The area under oats has been reduced in the past decades in the world at the expense of more productive grains, and according to FAO data, in 2022 oats was grown on 9,562,497ha (mostly in the countries of Eastern and Northeastern Europe), Table 2. According to FAO statistical data in the world in 2022 there were 9,562,497 ha under oats. The average grain yield was 2,360 kg ha-1, and the total production was 22,571,618 tons. The largest areas under oats by continent were Europe with 5,390,227 ha or 56.37% and America with 2,387,873 ha or 24.97%. Europe recorded the highest average grain yield of 2,526 kg ha-1 with a total production of 13,614,876 tons, while America recorded an average grain yield of 2,380 kg ha-1 and total production was 5,683,700 tons, table 1.

Table 2. Areas, yields and production of oats in the world in 2022.

Parameter	Area, ha	Yield, kg ha^{-1}	Production, t	Share area,%
World	9,562,497	2,360	22,571,618.53	100.00
Europe	5,390,227	2,526	13,614,876.00	56.37
America	2,387,873	2,380	5,683,700.71	24.97
Oceania	1,075,574	1,788	1,922,794.62	11.25
Asia	581,092	2,036	1,183,130.74	6.08
Africa	127,731	1,308	167,116.45	1.34
EU	2,553,510	2,933	748,848.00	26.70

Source: FAO, 2023

In our country, according to data for 2021, oats are grown on an area of 14,503 ha. In total, 44,176 tons of grains were produced. Average grain yields of 3,046 kg ha-1 are 20.58% higher than the average of European countries, or about 30% higher than the average world yields. In lowland areas, especially on areas next to large buildings of domestic ruminants, oats are mostly grown in fodder mixtures for fresh biomass that is used fresh or for the preparation of silage and haylage. Grain production is mainly concentrated in the hilly and mountainous areas of the central part of Serbia.

Productive characteristics of oat varieties in Serbia

The average value of the number of spikelets per panicle was 24.52. The values of the number of spikelets per panicle varied from 22.25 in the control variant to 26.20 in the variant with digestate.

Year and variety had a statistically significant influence on the values of the number of spikelets per panicle. The interaction of the examined factors had no statistical significance for the examined factor, tables 3, 4 and 5, graphs 1a and 2.

The average value of grain weight per panicle was 1.47 g. The values of grain mass per panicle varied from 1.36 g in the control variant to 1.58 g in the variant with digestate. Year and variant and the interaction of the examined factors had no statistical significance for the examined factor, tables 6, 7 and 8, graphs 1b and 2.

Table 3. Productivity parameters of oats in the control and in the variant with digestate

Parameter		Varijant	2021	2022	Average	IV
Number of spikelets per panicle		Control	24,53	21,17	22,85	3,36
		Digestat	26,90	25,50	26,20	1,40
		Average	**25,72**	**23,34**	**24,52**	**2,38**
Mass of grains per panicle		Control	1,20	1,51	1,36	0,31
		Digestat	1,57	1,58	1,58	0,01
		Average	**1,39**	**1,55**	**1,47**	**0,16**
LSD	**No. of spikelets per panicle**			**Mass of grains per panicle**		
	Year	**Variant**	**Yx Var.**	**Year**	**Variant**	**Y x Variant**
0,5	1,336	1,337	6,135	0,303	0,304	4,297
0,1	6,308	6,308	8,922	0,442	0,442	6,253

Tabela 4. Anova for number of spikelts per panicle

Parametar	SS	Degr. of Freedom	MS	F	p
Number of spikelts per panicle	7217,708	1	7217,708	680,4878	0,000000
	17,041	1	17,041	1,6066	0,240616
	33,667	1	33,667	3,1742	0,112671
	2,901	1	2,901	0,2735	0,615170
	84,853	8	10,607		

Table 5. Number of spikelts per panicle of oats

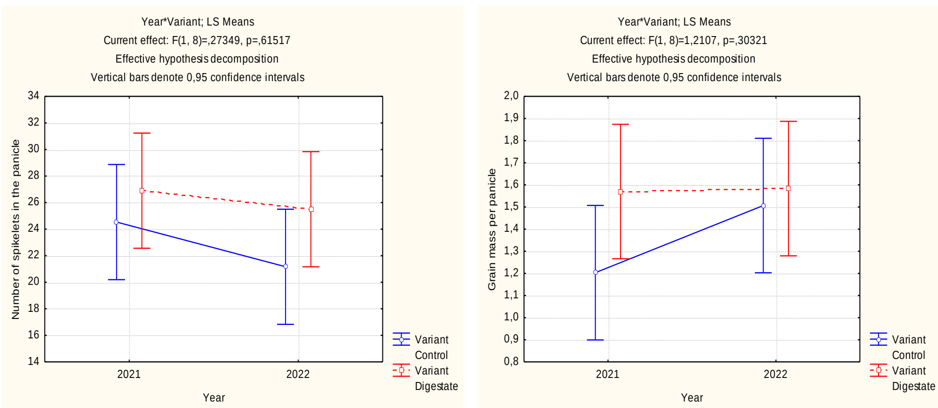
Effect	Level of factor	Level of factor	N	Mean	Std. Dev.	Std. Error	-95,0%	+95,0%
Total			12	24.53	3.547	1.024	22.270	26.779
Year	2021		6	25.72	4.151	1.694	21.360	30.073
Year	2022		6	23.33	2.655	1.084	20.546	26.119
Variant	Control		6	22.85	4.280	1.747	18.358	27.341
Variant	Digestate		6	26.20	1.625	0.663	24.494	27.905
Year x Variant	2021	Control	6	24.53	5.970	3.446	9.702	39.364
Year x Variant	2021	Digestate	6	26.90	1.800	1.039	22.420	31.371
Yearx Variant	2022	Control	6	21.17	1.286	0.742	17.973	24.361
Year xVariant	2022	Digestate	6	25.50	1.374	0.794	22.084	28.915

Tabela 6. Anova for mass of grains per panicle of oats

Parametar	SS	Degr. of Freedom	MS	F	p
Mass of grains per panicle	25.784	1	25.784	494.894	0.000000
	0.075	1	0.075	1.4435	0.263927
	0.147	1	0.147	2.8293	0.131060
	0.063	1	0.063	1.2107	0.303206
	0.416	8	0.052		

Table 7. Mass of grain per panicle of oats

Effect	Level of factor		N	Mean	Std. Dev.	Std. Error	-95,00%	+95,00%
Total			12	1.465	0.25	0.073	1.305	1.626
Year	2021		6	1.386	0.27	0.110	1.103	0.669
Year	2022		6	1.545	0.23	0.094	1.304	1.785
Variant	Control		6	1.355	0.27	0.109	1.075	1.634
Variant	Digestate		6	1.576	0.21	0.082	1.366	1.787
Year x Variant	2021	Control	6	1.203	0.21	0.124	0.669	1.737
Year xVariant	2021	Digestate	6	1.570	0.18	0.107	1.106	2.034
Year x Variant	2022	Control	6	1.506	0.25	0.143	0.889	2.125
Year x Variant	2022	Digestate	6	1.583	0.25	0.147	0.948	2.218



a) b)

Graph 1. Interaction Y x V for number spikelets in panicle (a) and grain mass per panicle (b)

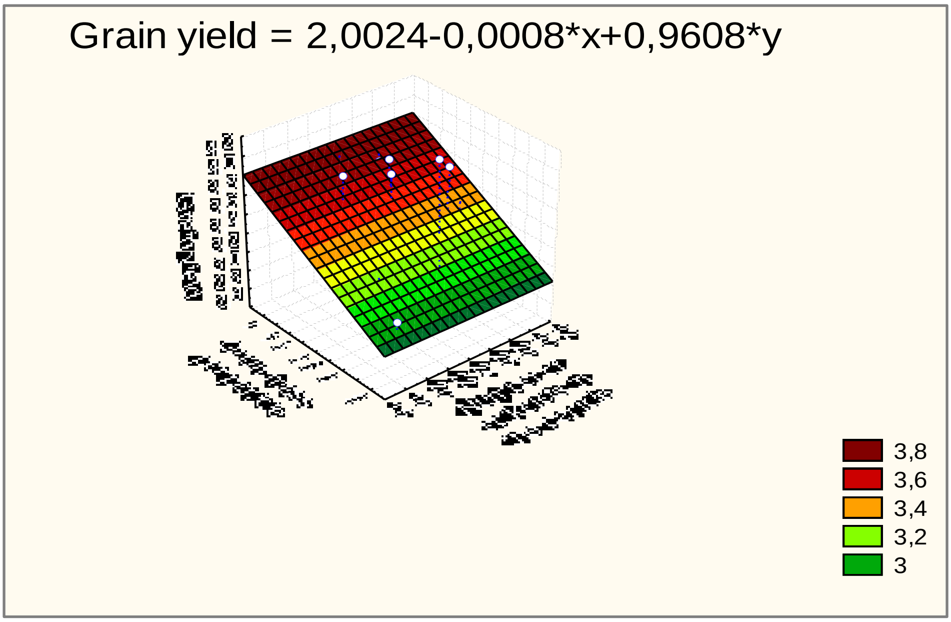
Correlation analysis of the studied oat traits

Correlation coefficients based on all traits tested during 2021-2022 had positive values (Table 8). Over a two-year study period, highly significant positive correlation coefficients were found between grain yields and grain mass per panicle (r=0.50**).

Table 8. Correlations between the analyzed traits

Traits	GY	NSP	GMP
Grain yield - GY	1.00	0.14	0.50**
Number spikelets in panicle - NSP	0.14	1.00	0.30
Grain mass per panicle - GMP	0.50*	0.30*	1.00
* significant at 0.05; **significant at 0.01			

Significant positive correlations were found between Number spikelets in panicle - NSP and grain mass per panicle (r=0.411*). A strong positive correlation between small yields and grain weight has been found by many researchers (Terzic et al., 2018), medium (Đekić et al., 2014; Güngör et al., 2017), while weak positive dependence has been identified by Rajičić et al., (2020).



Graph 2. 3D for number spikelets in panicle (a) and grain mass per panicle (b)

Oats nutritional value

Oat genotypes (winter and spring) differ in the chemical composition of the grain, especially in protein content. The protein content of oat grains is 16.9g, fat content 6.9g, crude fiber content 12.1g, Table 9.

Table 9. Oats nutrution value

Nutrient	**Amount per 100g of oats** (% of recommended daily intake)
Protein, g	16.9
Total fat, g	6.9
Saturated fat, g	1.2
Monounsaturated fat	2.2
Sodium, mg	6.0
Total Carbohydrate, g	57.1
Dietary Fiber, g	12.1
Sugar, g	1.1
Potassium, mg	310.1
Calcium, mg	48.1
Iron, mg	4.2

Jordanovska et al., (2018) points out that the protein content of oat grains varied from 12-15%, fat content from 4-6.5%, crude fiber content from 12.2-12.5%.

There was a significant effect ($p<0.001$) of both the variety and environment on protein, oil and β-glucan contents which, averaged over all varieties, ranged from 7.77 to 12.33%, 6.48 to 7.83% and 3.16 to 4.88%, respectively, across environments (Howarth et al., 2021).

Conclusion

Oat grain is used for food, non-food and feed products due to its unique grain qualities. Known as a natural functional food, oats for human consumption are responsible for numerous health benefits beyond basic nutrition.

Over a two-year study period, highly significant positive correlation coefficients were found between grain yields and grain mass per panicle (r=0.50**). Significant positive correlations were found between Number of spikelets in panicle - NSP and grain mass per panicle (r=0.411*).

The results showed that year and digestate had a statistically significant effect on the number of ears per panicle of oats and that higher values of grain weight per panicle were achieved in the digestate variant compared to the control variant. The digestate had a significant effect on the increase in oat productivity parameters and its application in the oat crop is justified. By improving the quality of oat varieties for food, non-food and fodder products through plant breeding, new opportunities will be created for the future of this culture.

Acknowledgments

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TRANSITIONING FROM TRADITION TO INNOVATION: ASSESSING THE STATE OF APPLE CULTIVATION IN BERANE REGION, MONTENEGRO

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Abstract

Apple is a widespread continental fruit species within Montenegro, and it is dominant in the Lim River valley (Polimlje). The territory of Berane represents a central part of this region, offering suitable agro-ecological conditions for apple cultivation, which also confirms the presence of a large number of plantations with a total of 41,000 trees. This paper presents certain trends in apple cultivation and yield in this area created on the basis of official statistical data, including challenges and opportunities related to the growing and processing of apples over a two-decade period. Apart from the traditional methods of analysis used in fruit growing research, the study employed SWOT, PESTEL, and GAP analyses to comprehensively evaluate the current state of apple production. The analysis revealed that apple production is a dominant agricultural activity. An insight into the current state of apple production including an analysis of cultivated genotypes, growing technology, and yield fluctuations, led to the conclusion that the major problems are an inadequate assortment and outdated cultivation technology. In this regard, the study emphasizes that introducing more productive apple cultivars, using intensive growing systems and modern techniques, and encouraging economic opportunities are key segments for improving production. The outcomes have implications beyond agricultural production, extending to the local economy and community. By modernizing apple orchards, the region can not only secure a sustainable income source for the local population but also contribute to regional development.

Key words: Malus domestica Borkh., production, trends, agro-ecological conditions.

Introduction

Apple *(Malus domestica* Borkh.*)* is widely cultivated and ranks third major fruit, after citrus and banana, with respect to global fruit production according to FAO statistics in 2019 (FAO, 2020), and it is widespread on all continents in different environmental conditions (Lespinass, 1992), which indicates its extreme adaptability to changing environmental conditions (Ercisli, 2004; Gharghani et al., 2009; Radivojevic et al., 2014). Aple fruits also have an interesting nutritional value, and their consumption has been associated with beneficial health effects (Millán-Laleona et al., 2023). The economic importance of apple lies in the fact that its fruits can be consumed fresh throughout the year (Ercisli, 2004). They can also be dried and processed into numerous products such as juice, jam, compote, puree, vinegar, wine, brandy, concentrates etc. (Milenkovic and Lukic, 2008). Autochthonous apple varieties are still keeping their importance in Montenegro and they are valuable resources as human food and an important part of rural landscape (Bozovic et al., 2016).

On the basis of fruiting type and branch architecture, apple trees are classified into four ideotypes: columnar, standard, spur, and weeping, with different branch angles (Lespinass, 1992). Fruit tree architecture determines the compactness of the canopy structure, the amount of shadowing between branches, and the extent of ventilation and light transmission to the lower part of the tree. Branching can affect tree shape, in turn influencing fruit yield and quality (Costes et al., 2010). In apple production, branch angles are manually widened to promote early flowering and fruiting. Investigation of branch angle-related genes should therefore contribute to apple tree breeding and genetic improvement (Li et al., 2022).

Apple cultivation plays a pivotal role in shaping agricultural landscapes and economies across the world. Its significance stems from its widespread adaptability, making it a staple in various environments. Berane, a municipality located in Montenegro, stands as a prime example of this adaptability, with a rich history of apple cultivation fostered by its agro-ecological conditions and traditional practices. Its unique geographical position within the valley of the river Lim, coupled with its moderately continental climate with cold winters and warm summers, underscores the significance of studying apple cultivation in this locality.

The aim of the work was to analyse the growing of apple in the region of Berane for a period of two decades of this century (2000–2021), and to establish certain trends in the cultivation and yield of apple in the agro-ecological conditions of Montenegro based on statistical data.

While anecdotal knowledge and localized practices have contributed to apple cultivation in Berane, a comprehensive analysis incorporating systematic data and insights from multiple dimensions is essential. Prior to this study, limited empirical research had been conducted on the trends, challenges, and opportunities in this specific context. By scrutinizing statistical data and applying analytical frameworks such as SWOT, PESTEL, and GAP analyses, this study endeavours to provide a holistic perspective that extends beyond previous subjective understandings.

The study's significance transcends the immediate scope of apple cultivation, resonating with broader implications for local economies, rural livelihoods, and sustainable agricultural practices. The outcomes of this research hold the potential to guide informed decisions, driving the transition towards modernized cultivation techniques, varietal diversification, and the integration of advanced technologies. In doing so, this study seeks to not only address the challenges faced by apple growers in Berane but also to pave the way for a resilient, profitable, and sustainable apple cultivation sector that aligns with the region's agro-ecological strengths.

In the subsequent sections, we delve into the methodology employed to assess the current state of apple cultivation in Berane, followed by the presentation and analysis of the results garnered through empirical investigation and analytical frameworks. Ultimately, the study strives to contribute to our understanding of local agricultural systems, foster economic development, and propel Berane's apple cultivation sector into a promising future. The intricate dynamics of apple cultivation in Berane, its challenges, and the avenues for progress will be unveiled, offering insights that can potentially resonate with similar contexts globally.

Materials and Methods

Study area. Montenegro exhibits remarkable diversity in view of geographical features, encompassing a wide range of landscapes including sandy and rocky coastlines, karst plateaus, expansive fields, towering mountains leaving behind glacial influences, intricate canyons, and more. All of this is contained within a compact area of just 13,812 square kilometers and an elevation span of 2,535 meters. The region boasts a Mediterranean climate characterized by warm and dry summers and autumns, as well as relatively cold winters accompanied by substantial inland snowfall, as noted by Kerckhof et al., (2016) and Zejak et al., (2022).

Berane, situated in the north-eastern part of Montenegro, resides within the valley carved by the Lim River (the city center is positioned precisely at the coordinates 42°50'34.9"N 19°52'22.5"E - 42.843038, 19.872928), the city is bordered by the Bjelasica Mountain peaks to the west and the Cmiljevica Mountain peaks to the east. Its northern boundary is marked by the Tivranska gorge, while the southern perimeter is defined by the Sekularska River inflow to Lim and Vinicka. The Berane valley areais of 367 square kilometers according to Spalevic (1999), while the broader Municipality extends across 496 square kilometers. The Lim River meanders through the heart of this basin, effectively splitting it into two nearly equal halves and receiving contributions from ten tributaries within its watershed (Spalevic, 2011).

Spanning vertically from an altitude of 670 meters above sea level at the Lim River's entrance into the Tifran gorge, to a height of 2,139 meters at the peaks of Bjelasica Mountain, the Berane valley exhibits a notable elevation difference of 1,469 meters, by extending horizontally for 32 kilometers along the east-west axis (the Dzakovica-Bjelasica Mountain peaks direction), and 10 kilometers downstream from the Lim River's bed in the north-south direction (Tifran canyon-inflow stretch of the Sekularska River into the Lim) dimensions.

The population within the Municipality of Berane displayed consistent growth, from 27,646 residents in 1948 to a peak of 42,060 in 1981. However, this trend was subsequently reversed, with the population declining to 38,953 by 1991 (Monstat, Strategic Development Plan of the Municipality of Berane for the period 2012–2017). According to the findings of the Montenegro population census conducted by Monstat in 2011, the municipality of Berane is home to 33,970 inhabitants, accounting for approximately 5.48% of Montenegro's total population.

Figure 1. Area of Polimlje with Berane valley

Methods

The research objective was accomplished using data sourced from the Montenegro Directorate for Statistics (Monstat). This study conducts a comparative analysis of annual statistical information concerning land areas, tree quantities, and apple yields.

A combination of analytical frameworks was employed to comprehensively analyze the status and potential of apple cultivation in Berane, Montenegro (2000–2021).

PESTEL Analysis. The PESTEL analysis is a strategic tool used to assess the external macro-environmental factors that can impact an organization, project, or research study. PESTEL stands for political, economic, socio-cultural, technological, environmental, and legal factors. This analysis provides a comprehensive view of the external forces that might influence decision-making, strategy formulation, and overall success. By examining these factors, researchers can identify opportunities and threats that the entity under consideration might encounter. The PESTEL analysis was used to evaluate the external factors that influence apple cultivation, including political, economic, socio-cultural, technological, environmental, and legal aspects. This aided in understanding the broader contextual forces that shape the industry.

SWOT Analysis. The SWOT analysis is a structured framework employed to evaluate the internal strengths and weaknesses, as well as the external opportunities and threats of a subject of study, whether it's an organization, project, or area of interest. The goal is to identify the inherent advantages and challenges within the context and align strategies that capitalize on strengths and opportunities while mitigating weaknesses and threats. This analysis aids in making informed decisions and developing effective action plans. The SWOT analysis was applied to assess the internal strengths and weaknesses of local apple cultivation practices, along with the external opportunities and threats faced by the sector. By juxtaposing these factors, the SWOT analysis highlighted areas for improvement and potential avenues for development.

GAP Analysis. GAP analysis is a method used to identify the disparities, or "gaps", between the current state and the desired state of a subject. It involves evaluating where an entity is presently (actual performance) and where it aims to be (desired performance). By comparing these two states, the gaps become apparent, which may pertain to performance metrics, resource allocation, processes, or other aspects. Gap analysis assists in setting realistic goals, designing strategies for improvement, and identifying necessary actions to bridge the gaps. Additionally, a GAP analysis was conducted to identify the gaps between the current state of apple cultivation in Berane and the desired state. This involved comparing the existing conditions, challenges, and opportunities with the envisioned future state. The GAP analysis facilitated the formulation of actionable recommendations and strategies to bridge the identified gaps.

The combination of these three analytical tools enabled a multidimensional evaluation of the apple cultivation sector, shedding light on its existing challenges, untapped potentials, and pathways for advancement. This robust methodology provided valuable insights for the subsequent analysis and discussion presented in this study.

Result and Discussion

Berane Municipality stands as the Montenegro's fifth-largest administrative region. Within its bounds, the urban population totals 11,073 individuals (32.6%), while in rural areas there are living 22,897 residents (67.40%). Notably, the municipality's agricultural landscape spans a substantial 26,070 hectares, as indicated in Table 1. Pastures dominate this land utilization, occupying 10,088 hectares, followed by arable land at 3,435 hectares and orchards covering 910 hectares. The agricultural contributions from Berane hold significant weight in Montenegro's overall agricultural output, a fact highlighted by MONSTAT (2023).

Table 1. Land structure in Berane, 2018.

Land category		**Area (in ha)**
Agricultural land		26070
	Arable land	3435
	Orchards	910
	Meadows	8049
	Pastures	10088
Forest land		20935
Barren land		2171
TOTAL		49176

Source: Secretariat for Agriculture, Municipality of Berane,-Strategic development plan of the municipality of Berane for the period 2019-2023

Further insights into the fruit production composition within the Berane municipality are detailed in Table 2.

Table 2. The structure of fruit trees in the area of the of Berane

Order No.	Fruit type	Number of trees in the genus
1.	Plum	290,500
2.	Apple	41,100
3.	Pear	13,600
4.	Cherry	2,580
5.	Sweet Cherry	2,000
6.	Walnut	1,900
7.	Raspberry	about 3 ha

Source: Strategic plan of rural development of the municipality of Berane for the period 2020 –2024.

Among continental fruits, apples and plums rank as the most prevalent within the Berane municipality. A significant count of 41,100 apple trees in the genus populates the region (Strategic Plan of Rural Development of the Municipality of Berane for the period 2020–2024).

GAP analysis, a SWOT analysis, and a PESTEL analysis for the given apple cultivation in Berane, Montenegro (2000–2021) are presented in the tables 3, 4 and 5.

Table 3. GAP analysis for the apple cultivation in Berane (2000-2021)

Current Situation (What is): **Outdated Assortment and Technology**: Apple cultivation in Berane relies on outdated apple varieties and cultivation methods, leading to suboptimal yields and production efficiency. **Decreasing Fruit-Bearing Trees**: The number of fruit-bearing apple trees is declining, indicating a need for rejuvenation and modernization efforts. **Brandy Production Focus**: The primary purpose of apple cultivation appears to be brandy production, which might limit the potential for diversified market offerings. **Underutilized Agricultural Land**: Despite the availability of substantial agricultural land, there seems to be an underutilization of available space for apple cultivation.
Desired Future State (What should be): **Modern Cultivation Techniques**: Transition to modern cultivation techniques, including intensive planting, efficient irrigation, and proper pest management, to increase yields and quality. **Varietal Diversification**: Introduce and promote more productive apple varieties suitable for the region, aligning with market demand for both fresh consumption and processed products. **Increased Yields**: Improve yields per tree and unit of area through better cultivation practices, resulting in higher overall production. **Market Expansion**: Broaden the focus from brandy production to include fresh apple consumption and processing for various products like juice, compote, and jam.
Gaps (What needs to be done): **Technology Upgrade**: Implement training programs to educate local farmers about modern cultivation techniques and technologies, encouraging them to adopt these practices. **Varietal Revitalization**: Develop strategies to introduce and popularize more productive apple varieties while preserving local heirloom varieties. **Investment in Infrastructure**: Establish storage and transportation infrastructure to ensure efficient delivery of apples and products to local and potential markets. **Market Diversification**: Encourage farmers to explore new market opportunities beyond brandy production, such as fresh apple sales and various processed products. **Knowledge Dissemination**: Develop extension services and workshops to disseminate knowledge about modern apple cultivation techniques, best practices, and market trends.

By addressing the listed gaps and working towards the desired future state, the apple cultivation sector in Berane can potentially experience increased productivity, economic growth, and improved market competitiveness.

Table 4. A SWOT analysis for the apple cultivation in Berane

Strengths:	Weaknesses:
Favorable Agro-Ecological Conditions: The region of Berane, Montenegro, offers ideal agro-ecological conditions for apple cultivation, including a climate with warm summers and cold winters. **Tradition in Cultivation**: There is a historical tradition of apple cultivation in the area, indicating the potential knowledge and experience of local farmers. **Varietal Diversity**: The region boasts a diverse assortment of apple varieties, including local ones, which could contribute to unique flavors and potential marketing opportunities. **Abundant Land Availability**: There is a significant amount of agricultural land available for cultivation in Berane, providing room for expansion of apple orchards.	**Outdated Assortment**: The predominant use of older and less productive apple varieties hampers the potential for high yields. **Inadequate Cultivation Techniques**: The presence of old plantations and outdated cultivation methods contributes to lower yields and reduced production efficiency. **Decreasing Fruit-Bearing Trees**: The number of fruit-bearing apple trees is decreasing over time, possibly due to a lack of proper maintenance and modernization efforts. **Brandy Production Focus**: The primary purpose of apple cultivation seems to be the production of brandy rather than fresh consumption or other processed products, limiting the potential market opportunities.
Opportunities:	**Threats:**
Modernization and Intensification: Shifting towards modern cultivation methods and adopting intensive production systems could significantly improve yields and overall productivity. **High Local Demand**: Given the rural population's prevalence and the potential for increased income, there's an opportunity to cater to the local demand for fresh apples and other apple-derived products. **Diversification of Varieties**: Introducing more productive and commercially viable apple varieties	**Climate Change**: Unforeseen shifts in climate patterns could impact apple cultivation, affecting yields and overall production. **Market Competition**: The global apple market is competitive; without modernization, the local produce might struggle to meet quality and quantity demands. **Lack of Infrastructure**: Insufficient infrastructure and technological advancements might hinder the transition to modern cultivation practices.

could lead to increased production and wider market reach. **Income Generation**: Improving apple cultivation could become a substantial income source for the local population, contributing to economic development and progress in the region.	**Lack of Knowledge Transfer**: If the knowledge of efficient cultivation practices is not effectively transferred to the local farming community, the potential benefits might not be realized.

The apple cultivation in Berane, Montenegro, has the potential for growth and economic benefit, especially if there's a shift towards modernization, improved cultivation techniques, and the adoption of more productive varieties. The favourable agro-ecological conditions and available land offer opportunities for increased income and economic development. However, challenges such as outdated practices, limited variety focus, and the need for proper knowledge dissemination must be addressed to fully realize the potential of apple cultivation in the region.

Table 5. PESTEL analysis for the apple cultivation in Berane

Political: **Agricultural Policies**: Government policies that promote or hinder agriculture, including subsidies, regulations, and trade agreements, can impact apple cultivation in terms of funding, support, and market access. **Land Use Regulations**: Regulations governing land use and agricultural practices can influence the expansion and intensification of apple orchards.
Economic: **Market Demand**: Economic conditions, purchasing power, and consumer preferences influence the demand for apples and related products, affecting local farmers' potential income. **Income Generation**: The success of apple cultivation could contribute significantly to the income generation of the local population and the municipality's economic development. **Market Prices**: Fluctuations in market prices for apples can affect profitability and economic feasibility of cultivation.
Socio-Cultural: **Tradition and Knowledge**: Local tradition and knowledge of apple cultivation practices can shape the adoption of modern techniques and the preservation of valuable varieties. **Consumer Preferences**: Socio-cultural factors influence the types of apples in demand, as well as the products (e.g., fresh apples, brandy) derived from them.
Technological:

Modern Cultivation Techniques: Adoption of modern technological practices, such as efficient irrigation methods and pest management, could enhance apple production. **Infrastructure**: Availability of modern infrastructure, including storage facilities and transportation networks, affects the ability to deliver products to markets effectively.
Environmental: **Climate Change**: Changing climatic conditions can impact apple growth and production, leading to shifts in yield and quality. **Biodiversity**: The preservation of local apple varieties contributes to biodiversity and can be influenced by environmental awareness and conservation efforts.
Legal: **Environmental Regulations**: Compliance with environmental regulations related to pesticide use, waste disposal, and soil conservation can impact cultivation practices. **Intellectual Property Rights**: Protection of unique apple varieties through intellectual property rights can impact the availability and distribution of certain cultivars.

The PESTEL analysis (Table 5) highlights that apple cultivation in Berane, is influenced by a variety of factors across political, economic, socio-cultural, technological, environmental, and legal dimensions. Understanding and effectively addressing these factors can play a crucial role in shaping the success and sustainability of apple cultivation in the region.

Fruit growers should use the region's favourable agro-ecological conditions as an advantage by selecting apple varieties that thrive in the climate conditions of Berane. Considering introducing more productive apple varieties that align with market demands and enhancing both yield and quality with modern cultivation methods such as intensive planting, efficient irrigation, and integrated pest management to increase productivity is highly recommended. Education and training should not be overlooked and attending workshops and training programs that focus on advanced cultivation techniques and best practices to stay updated with the latest industry trends is a high priority for serious fruit growers. The strengthening of collaboration among local fruit growers to share experiences, exchange knowledge, and collectively address challenges is of great importance. The fruit growers should further explore opportunities beyond brandy production by considering producing fresh apples and various processed products like juice, jam, and compote to cater to diverse consumer preferences. All the process from the growing to the processing should strive to implement environmentally friendly practices by following recommended guidelines for pesticide use, waste disposal, and land conservation. Furthermore, while introducing new varieties, the growers should remember to preserve local heirloom varieties, which are valuable resources for the region's heritage and biodiversity.

Infrastructure investment is something that should be the grower's constant pressure on state services and the government's advocacy for the establishment of storage facilities and improved transportation networks to ensure timely delivery of produce to markets. The new burning issue of climate change should be taken into consideration, and growers should adapt to climate change by staying informed about changing climatic conditions and adjusting their cultivation strategies accordingly to mitigate potential risks. The importance of continuous learning is a key for every serious grower and processor who should stay curious and open to learning about innovative technologies and practices that can contribute to improved yields and higher-quality produce. Finally, but not least important, is to follow the market, both local and global, by keeping a pulse on consumer preferences and market trends to tailor production to meet evolving demands. By implementing the listed recommendations of these key messages, growers and processors can enhance apple cultivation practices in the studied region, boost yields, contribute to the local economy, and ensure the sustainability of the industry in Berane and Montenegro.

Conclusions

This research has provided a comprehensive analysis of the apple cultivation sector in Berane, Montenegro, spanning the years 2000 to 2021. Through the utilization of SWOT, PESTEL, and GAP analyses, the study unearthed crucial insights into the challenges and opportunities faced by local apple growers.

The analysis highlighted the dominance of outdated cultivation practices and assortment, leading to suboptimal yields and hindering economic growth. The declining number of fruit-bearing trees further emphasized the need for modernization efforts. However, the study also identified significant strengths, including the region's favourable agro-ecological conditions, tradition in cultivation, and potential for varietal diversity.

Recommendations arising from the analysis provide a roadmap for transformative change. The adoption of modern cultivation techniques, intensification, and the introduction of more productive apple cultivars stand as key strategies to enhance yield, quality, and economic viability. Market diversification, technological upgrades, and infrastructure development are pivotal for expanding the sector's reach and profitability. Furthermore, the preservation of old, local genotypes and environmentally friendly practices are central to sustainability.

The outcomes of this research extend beyond the realm of agriculture. A successful transition to modernized apple cultivation practices can generate sustainable income for the local population, stimulate municipal development, and contribute to the regional economy. The study underscores the vital connection between agricultural practices, economic prosperity, and community well-being.

In summary, this research illuminates the potential for Berane's apple cultivation sector to undergo a transformation that aligns with market demands, modern techniques, and sustainable practices. By bridging the identified gaps and implementing the proposed recommendations, local apple cultivation can transition into a dynamic, competitive, and resilient industry. The lessons learned from this study are applicable not only to Berane but also to similar agricultural contexts worldwide, signifying the broader significance of this research's findings.

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THE EFFECT OF SEASON ON THE PREVALENCE RISK AND EFFECT OF MASTITIS PREVALENCE RISK ON DAILY MILK YIELD

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Abstract

Aiming determination of the variability in the mastitis prevalence risk and the effect of prevalence risk on successive daily milk yield of dairy cows (Holstein and Simmental breed) test-day records collected from 2005 to 2022 were used. As a mastitis risk indicator, daily lactose content was used. The highest mastitis prevalence risk was determined, in both breeds, during the winter period and the lowest during the spring season, with the lower prevalence observed in Simmentals. The effect of mastitis prevalence risk on the cow's productivity at successive milk recordings was more pronounced in the Holstein breed that experienced the higher increase at the I. successive milk recording and high total increase during the analyzed 4-month period than the Simment al., Observed could indicate better overall health and higher resistance of the Simmental breed, as well as a higher recovery capability from subclinical mastitis of Holstein cows.

Key words: Dairy cows, mastitis prevalence risk, daily milk yield, daily lactose content.

Introduction

A sustainable dairy cattle farm implies optimized management and genetically highly valuable animals that will provide high production of high-quality milk. Highly productive animals are frequently sensitive and extremely demanding in terms of keeping conditions, feeding, and prevention. If the above is not at the highest level, a large number of different disorders or diseases often occur. The occurrence of any disorder or disease is highly correlated with a decrease in production and farm profitability. Several disorders can occur in dairy cattle, like mastitis (inflammation of the mammary gland, usually caused by a bacterial infection leading to reduced milk production, alters in milk composition, and significant economic losses due to a decrease in milk quality and quantity); lameness (any abnormality in a cow's gait or ability to walk caused by hoof injuries, infections, laminitis, and negatively affects mobility, productivity, and welfare of an animal); metabolic disorders (milk fever (hypocalcemia), ketosis (energy deficiency), acidosis, and fatty liver syndrome that occur due to energy and/or nutrients imbalances / deficiencies. Puppel and Kuczyńska (2016) stated that the differences between the genetic production potential and required ration regarding the animal's needs (energy and nutrients) frequently lead to the occurrence of various metabolic disorders. Metabolic disorders and mastitis are one of the priciest and most frequent disorders in dairy farms, and can occur in subclinical or clinical stage. Halasa et al., (2007) stated that both stages of mastitis (subclinical/clinical) cause significant financial losses for dairy farms due to quality and quantity reduction of milk production while Özkan Gülzari et al., (2018) emphasized the negative environmental effect of mastitis prevalence (an increase of greenhouse gas emissions per kg of milk).

Therefore, in order to enable sustainable dairy farming, it is crucial to determine the prevalence in the subclinical stage of certain disorders. Antanaitis et al., (2021) determined the increase in somatic cell counts and the decrease in lactose content in animals with subclinical mastitis. Silanikove et al., (2014) determined that the inflammation of the mammary gland results in cell damage and reduced lactose synthesis that lead to decreased lactose content in milk. Similarly, Pyorala (2003) pointed out that the daily lactose content could be used as an indicator of the prevalence of mastitis. Babnik et al., (2004) defined that daily lactose content lower than 4.5% indicates the prevalence risk of mastitis.

Due to the high importance of mastitis prevention and detection of accurate, uncostly indicators, this research aimed to determine the variability in the mastitis prevalence risk and the effect of prevalence risk on successive daily milk yield of dairy cows (Holstein and Simmental breed) based on test-day records and daily lactose content as a mastitis risk indicator.

Material and methods

For the purpose of statistical analysis test-day records of dairy cattle collected in the period from January / 2005 to December / 2022 in Croatia were used. Test-day records were obtained during regular milk recording according to the alternative milk recording method (AT4 / BT4). Logical control of data included correction for the stage of lactation (5 - 300 days), parity (1 - 10), and age at first calving (21 - 36 months). Furthermore, records with missing or meaningless information concerning the ICAR standards (ICAR, 2017) were deleted from the dataset. The corrected dataset included 3,953,637 test-day records of Holstein and 4,922,751 test-day records of Simmental cows. Accordingly, to daily lactose content (DLC), animals were divided into two classes: healthy animals (DLC > 4.5%); and cows in mastitis risk (DLC < 4.5%).

The mastitis prevalence risk was defined as the portion (%) of cows at risk and the portion (%) of healthy cows from the total number of animals. The mastitis prevalence risk was calculated for each recording season separately for each breed. The analysis of the effect of mastitis prevalence risk on subsequent daily milk yield (at I., II., III., and IV. successive milk recording) was performed on cows with a determined mastitis prevalence risk. The daily production on the day of the milk recording when the mastitis prevalence risk was determined was taken as a reference value. The mastitis index was defined regarding the number of days after the determined risk: D-0 = record on the milk recording when the risk of mastitis was determined, A-1 = within 35 days, A-2 = between 36 and 70 days, A-3 = between 71 and 105 days, and A-4 = more than 105 days. The effect of the mastitis prevalence risk on the daily milk yield was studied separately by recording season and by breed using east square means in MIXED procedure in SAS (SAS Institute Inc., 2019) by the following statistical model:

$$y_{ijklmno} = \mu + b_1(d_i/305) + b_2(d_i/305)^2 + b_3\, ln(305/d_i) + b_4\, ln^2(305/d_i) + A_j + P_k + Y_l + H_m + M_n + e_{ijklmno}$$

where:

$y_{ijklmno}$ = estimated daily milk yield;

μ = intercept;

b_1, b_2, b_3, b_4 = regression coefficients (lactation curve by Ali and Schaeffer, 1987);

d_i = days in milk i (i = 11 to 300 day);

A_j = fixed effect of age at first calving j (j = 21 to 36 month) *only for first parity,

P_k = fixed effect of parity k (k = 1., 2., 3., ≥ 4);

Y_l = fixed effect of year of milk recording l (l = 2005, … 2022);

H_m = fixed effect of herd size m (m = 1, … 6),

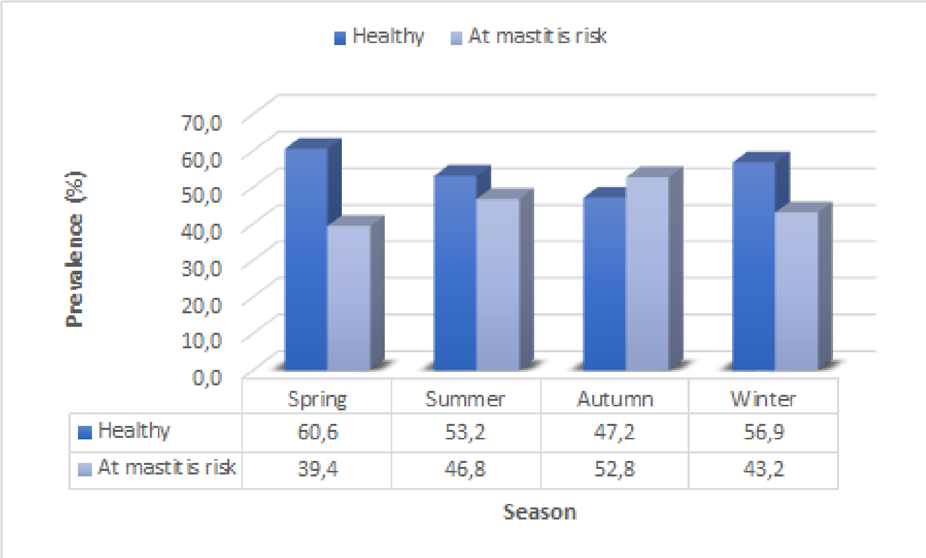
M_n = fixed effect of mastitis index n (n = D–0, A–1, A–2, A–3, A–4);

$e_{ijklmno}$ = residual.

The significance of the differences between the estimated LSmeans was tested by Scheffe's method of multiple comparisons in the MIXED procedure (SAS). Estimated differences in daily milk yield (kg) at successive milk recordings after the determination of mastitis prevalence risk was shown separately by breed.

Results and discussion

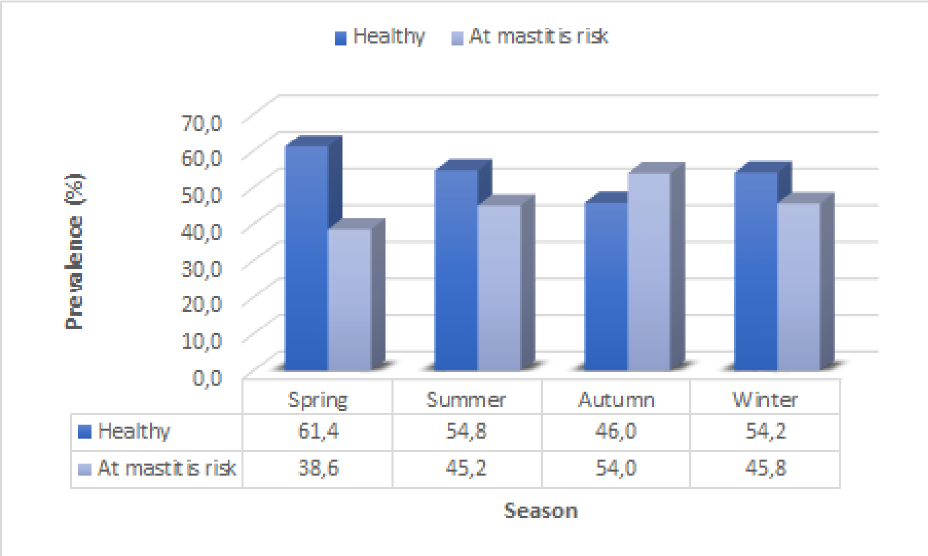
The prevalence of Holstein cows at mastitis risk and healthy ones concerning the season of milk recording is presented in Figure 1. The highest prevalence of animals at mastitis risk (indicating subclinical mastitis) was determined in the autumn season in the amount of 52.8%, while the lowest prevalence of animals with possible mastitis was observed in the spring season (39.4%). Furthermore, the highest prevalence of healthy animals in the amount of 60.6% was observed in spring, while the lowest prevalence of cows without mastitis-related problems was observed in the autumn season (47.2%).



Graph 1. Prevalence of healthy and cows at mastitis risk in concerning the season of milk recording for Holstein cattle

The prevalence of cows at mastitis risk and healthy cows for the Simmental breed concerning the season of milk recording is presented in Figure 2. The highest prevalence of cows with the indication of subclinical mastitis (at mastitis risk) was determined in the autumn season (54.0%), while the lowest prevalence of animals with probable mastitis-related problems was observed in the spring season (38.6%). Furthermore, the highest prevalence of healthy animals in the amount of 61.4% was observed in the spring season, while the lowest prevalence of cows without mastitis-related problems was observed in the autumn season (46.0%).

If the health status of both analyzed breeds is compared, the same prevalence trends are visible (the highest prevalence of mastitis risk during the winter period and the lowest during the spring season). In addition, the Simmental breed has a lower prevalence of animals at risk, i.e. a higher prevalence of healthy cows in all seasons, which indicates a better state of health and higher resistance of the Simmental breed.



Graph 2. Prevalence of healthy and cows at mastitis risk in concerning the season of milk recording for Holstein cattle

In the further analysis, only animals that were at risk of mastitis were included, and their daily milk production was monitored during the following four successive milk recordings (approx. 4 months after the detection of the risk of mastitis). Estimated differences in daily milk yield (kg) at successive milk recordings after the detection of mastitis prevalence risk for Holstein cows are presented in Table 1.

Table 1. Estimated differences in daily milk production (kg) at successive milk recordings after the detection of mastitis prevalence risk for Holstein cows concerning milk recording season

Recording Season	I. milk recording	II. milk recording	III. milk recording	IV. milk recording	Total
Spring	20.410	2.830	2.573	8.803	34.616
Summer	11.648	-1.0637	-0.571	8.167	18.181
Autumn	19.968	2.326	-1.078	-0.737	20.480
Winter	24.040	3.176	-1.933	5.183	30.467

Holstein cows, at first milk recordings after the detection of mastitis prevalence risk, experienced an increase in milk production in amount from 11.648 kg/day in the summer season to 24.040 kg/day during the winter season. During the spring season, Holstein cows had a constant increase in milk production at all analyzed milk recordings, while in other seasons cows experienced variations in milk production (depending on the number of successive milk recordings (I. – IV.). Furthermore, the highest total increase in milk production was determined in the amount of 34.616 kg/day was observed in the spring season, while the lowest total increase was observed in the summer season (18.181 kg/day).

Estimated differences in daily milk yield (kg) at successive milk recordings after the detection of mastitis prevalence risk for Simmental cows are presented in Table 2. The highest difference in milk production at the first successive milk recording was determined in the spring season (10.314 kg/day) while the lowest difference was in the autumn season. In further successive milk recordings, Simmental cows experienced a decrease in daily milk production except for the summer season at III. milk recording. The total difference in the analyzed period amounted from 4.347 kg/day in summer to -4.537 kg/day in winter season indicating higher recuperation ability of Simmental cows in the spring season.

Table 2. Estimated differences in daily milk production (kg) at successive milk recordings after the detection of mastitis prevalence risk for Simmental cows concerning milk recording season

Recording Season	I. milk recording	II. milk recording	III. milk recording	IV. milk recording	Total
Spring	10.314	-0.264	-1.225	-4.833	3.992
Summer	5.978	-1.694	0.244	-0.181	4.347
Autumn	3.943	-1.582	-2.374	-0.877	-0.890
Winter	7.692	-5.995	-3.643	-2.591	-4.537

If the performances of both breeds are compared, the impact of the mastitis prevalence risk on the productivity of the cow during successive milk recordings was highly pronounced in the Holstein breed with the higher increase at the I. successive milk recording and high total increase during analyzed 4-month period in comparison to Simmental breed. Observed could indicate a higher possibility of recovery from subclinical mastitis in Holstein than in Simmental cows.

Nobrega and Langoni (2011) state that cows had a higher level of lactose in the dry season than in the rainy season. Furthermore, Sharma et al., (2018) reported that the incidence of mastitis was highest during the early autumn or winter and rainy season. Similar results were found by Tomazi et al., (2018) who reported that the risk of intramammary infections was higher in the months with the highest temperatures and humidity in the environment, which is a combination that induces heat stress in dairy cows. Gantner et al., (2011) and Haygert-Velho et al., (2018) state that heat stress, expressed in summer and autumn, can contribute to variations in milk production and lactose content of lactating cows. Similarly, Weber et al., (2020), in a study conducted in Brazil, found a lower percentage of lactose and a higher number of SCC in the Holstein breed during summer and autumn. The same authors state that in winter and spring, the milk was of higher quality, while in the hotter months of summer and autumn, the quality and availability of forage and the frequency of mastitis (increased SCC) negatively affected the quality of milk.

Conclusion

The research results indicate the presence of variability in the mastitis prevalence risk and the effect of prevalence risk on milk production at successive recordings concerning the season of milk recording and the breed of dairy cows (Holstein and Simmental breed). Regarding the mastitis prevalence risk, the same trends were determined in both breeds with the highest prevalence of mastitis risk during the winter period and the lowest during the spring season. Furthermore, in the Simmental breed, a lower prevalence of animals at risk than in Holstein was determined in all seasons indicating better health and higher resistance of the Simmental breed. Regarding the effect of the mastitis prevalence risk on the cow's productivity at successive milk recordings, in the Holstein breed the higher increase at the I. successive milk recording and high total increase during the analyzed 4-month period than in Simmental was found. Observed could indicate a higher recovery capability from subclinical mastitis in Holstein than in Simmental cows.

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INFLUENCE OF MAIZE HYBRIDS ON SILAGE QUALITY

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Abstract

Maize (Zea mays L.) is the most important silage crop due to its low buffer capacity, high amount of dry matter and optimal concentration of soluble carbohydrates. Silage of maize is a process of anaerobic preservation by lactic acid fermentation, which reduces the possibility of loss of nutrients from harvest to consumption of animal feed. By silage maize, they try to preserve and maintain for a longer time the nutrients of the maize fresh biomass, without significant changes. In this study, the following maize hybrids were examined: H1- AS 160, H2- Pionir 1535 and H3- NS 6000. The quality of the green biomass of the examined maize hybrids was analyzed: content of protein, content of water and percentage of dry matter. The test results show that the percentage of crude proteins in the examined sample was the highest (2.72%) in hybrid H1, a slightly lower percentage (2.66%) in H2, and the lowest percentage of crude proteins was measured in hybrid H3. The percentage of dry matter in the tested sample was the highest (36.56%) in the NS 640 hybrid, slightly lower (35.05%) in the percentage in the AS 160 hybrid, and the lowest (33.80%) crude protein percentage was measured in the Pionir hybrid 1535. The percentage of moisture in the tested sample was the highest (66.20%) in H2, the slightly lower (64.95%) percentage of moisture was in hybrid H1, and the lowest (63.44%) percentage of moisture was measured in hybrid H3. Different hybrids have different levels of various maize plant components' quality.The results show that the hybrid had a significant impact on the examined quality parameters.

Key words: Maize hybrids, quality, green biomass, silage.

Introduction

Maize (*Zea mays* L.) is the predominant cereal crop in the Republic of Serbia grown on 53% of the harvested area under cereals (Grčak et al., 2020). The total 2021 world production of maize reached 1125.03 million metric tons (Shahbandeh, 2021). The basic economic importance of maize stems from its diverse use in human nutrition, domestic animals, industrial processing, and the volume of production. Maize has a very high biological fertility potential and is included in the group of field crops with the highest production of organic mass per unit area. The special economic importance of maize is also reflected in the fact that almost all above-ground biomass of the plant can be used. Today, more than 1,500 different industrial products are produced from the whole maize plant using a variety of technological procedures. In livestock production, the whole grain of maize is used as a concentrated fodder for feeding domestic animals, followed by above-ground biomass, fresh or for making silage. Maize straw can be used as a mat for domestic animals, as bulky animal feed or as a solid biofuel. Other side products, i.e. waste from industrial grain processing, are used as animal feed. It should be noted that many farmers use maize as a basic starch and protein component in the meals of all types and categories of domestic animals (Popović, 2010; Glamočlija et al., 2012; 2015; Božović et al., 2018; 2020; 2022; Ljubičić et al. , 2023a; 2023b).

Maize also has great agrotechnical importance, because it belongs to crops of high agrotechnics (deep soil cultivation, intensive nutrition and protection of plants from weeds). After the harvest, the soil has good physical and chemical properties, enriched with organic biomass of plowed harvest residues and is a good pre-plant for most field plants. Our country, in terms of arable land, is a significant producer of maize thanks to the fact that, according to agro-ecological conditions, we are in the maize belt zone. The average sown areas, yields, as well as the total grain production, in the past 11 years have shown significant variations. The consequences of these changes are less and less stable production in the conditions of the natural water regime and more and more frequent dry periods during the vegetation and non-vegetation periods (Popović, 2010; Živanović, 2012; Tabaković et al., 2013; Stanisavljević et al., 2015; Babić et al., 2010; 2016; 2022; Maksimović et al., 2018; Nikolić et al., 2021; 2022).

According to statistical data, in 2020, silage maize was grown on 2,711 hectares in Serbia. For small farmers, hybrids of other subspecies of maize are also interesting, for example durum maize, sugar maize, and popcorn maize, since their grain is increasingly taking an important place in people's diet. Due to the high demand on the world market, their products are interesting as export food items. By growing sweet maize in direct sowing, even on small areas, a significant profit is realized, because apart from the main grain product, after harvesting, a considerable amount of above-ground biomass of high nutritional and digestible value remains. This maize biomass can be used in feeding domestic animals in several ways. Storing silage is an old agricultural practice that began more than 3,000 years ago. In the United States of America and Western European countries, the preservation of animal feed by silage began at the end of the 19th century, and later the technology of silage spread to other parts of the world. Wider application of the new forage preservation technology occurred after the forties of the last century as a result of the development of mechanization for forage collection. Today, the process of preserving animal feed by silage is widely used all over the world. The advantage of the process of silage plant mass is that it is possible to harvest forage plants at the optimal stage of development and store them in silo until the moment of use. Silage involves the fermentation of soluble carbohydrates, which produces acids that preserve the fodder and store it in an unchanged form until the silo is opened. Nowadays, intensive livestock production is hard to imagine without storing silage. Silage of green biomass of fodder plants enables their earlier removal from production areas and more intensive use of land (Rakašćan et al., 2019a; 2019b). The importance of silage is reflected in the fact that the initial silage material changes little after the acidification of the green mass through natural fermentation processes or with the addition of certain additives. Silage can completely replace green fodder in livestock nutrition. Livestock feeding with silage is the closest substitute for green fodder, and it represents the basis of economic and modern animal husbandry (Đorđević et al., 2011). When feeding cattle with silage, high production of milk and meat can be maintained, as well as under conditions of feeding with green fodder. The aim of this study was to investigate the influence of maize hybrids on the examined quality parameters of green biomass.

Materials and Methods

Experiments with corn hybrids were set up in Ilandza, Alibunar municipality. The field trial was set up at the chernozem type of soil in Banat (Vojvodina) Province, Serbia. This chernozem type of soil is characterized by favorable physical and chemical properties, stable aggregates, good crumbly structure and good water permeability. The total area of the sample was 360 m^2, and the area of the settlement plot was 40 m^2. The following maize hybrids were tested: H1- AS 160, H2- Pionir 1535 and H3- NS 6000. Standard agricultural techniques for growing maize were applied. Maize was sown on April 29, 2022, with a mechanical seeder, at a depth of 7 cm. Among the protection measures, herbicides Basar and Rezon were used in the phase from the third to the fifth leaf.

The quality of the green mass of the tested maize hybrids was analyzed, namely the crude protein content, percentage of dry matter and water content, %. Maize silage on the calculation plots was done at waxy grain maturity on August 30, 2022, and on the same day samples were taken for yield and quality of green mass. The quality of green biomass was done in the laboratory for animal feed analysis of the Faculty of Agriculture in Belgrade-Zemun. Results of the study analyzed by standard analysis of variance (ANOVA) and present graphically.

Meteorological Data

During vegetation season, meteorological data, temperature and precipitation were very variable. Crop production is very sensitive to climate, and climate change significantly affects plant production (Popovic et al., 2011; 2020; 2021; Ikanović et al., 2018; Janković et al., 2019; Sekulić et al., 2023; Burić et al., 2023). Monthly precipitation and air temperatures for 2021 were taken from the Hydro-meteorological Institute of the Republic of Serbia for Ilandža, village in Serbia. It is situated in the Alibunar municipality, in the South Banat District, Vojvodina province (Table 1).

Tabela 1. Average temperature (°C) and total precipitation (mm) in experimental trial during 2022, Serbia (Ilandža)

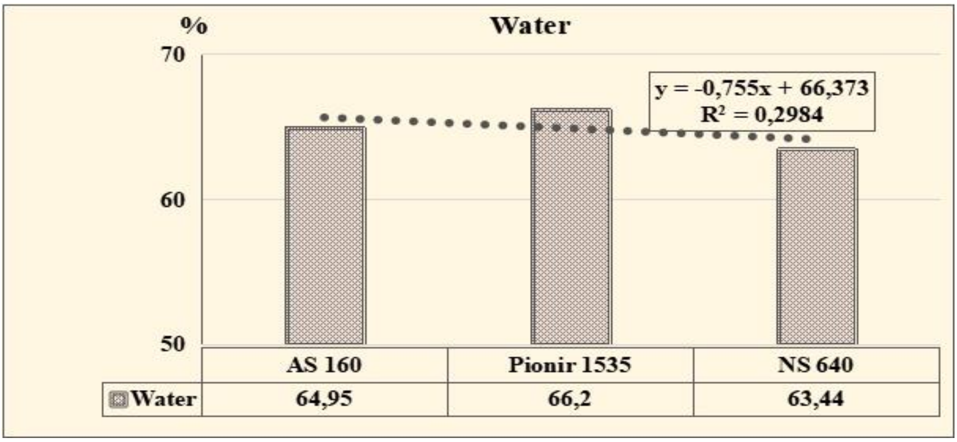
Parameters	April	May	June	July	August	Total/Average
Precipitation (mm)	41.16	73.00	77.00	74.00	46.00	311.20
Temperature (°C)	5.60	12.97	17.37	17.73	18.07	14.35

Average temperatures in the growing season in 2022 were 14.35 °C while total precipitation was 311.20 mm, Table 1.

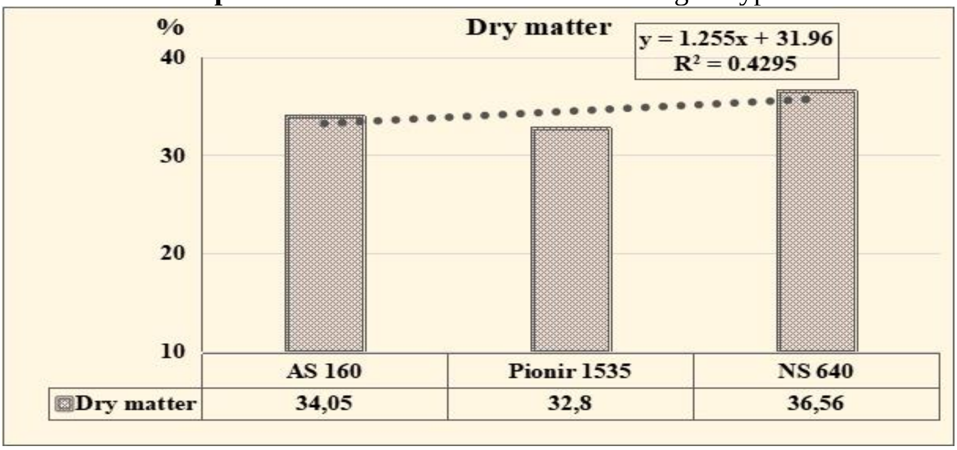
Results and Discussion

The chemical composition of the green biomass of maize hybrids was examined in the paper. The test results show that the percentage of crude proteins in the tested sample was the highest (2.72%) in hybrid H1, a slightly lower percentage (2.66%) in hybrid H2, and the lowest percentage of crude proteins was measured in hybrid H3. The percentage of dry matter in the examined sample was the highest (36.56%) in the NS 6000 hybrid, a slightly lower percentage (35.05%) in the AS 160 hybrid, and the lowest crude protein percentage (33.80%) was measured in the Pionir hybrid 1535. The percentage of moisture in the investigated parameter, the dry matter sample, was the highest (66.20%) in hybrid H2, a slightly lower (64.95%) percentage of moisture was in hybrid H1, and the lowest (63.44%) percentage of moisture was measured in hybrid H3, graphs 1-3.

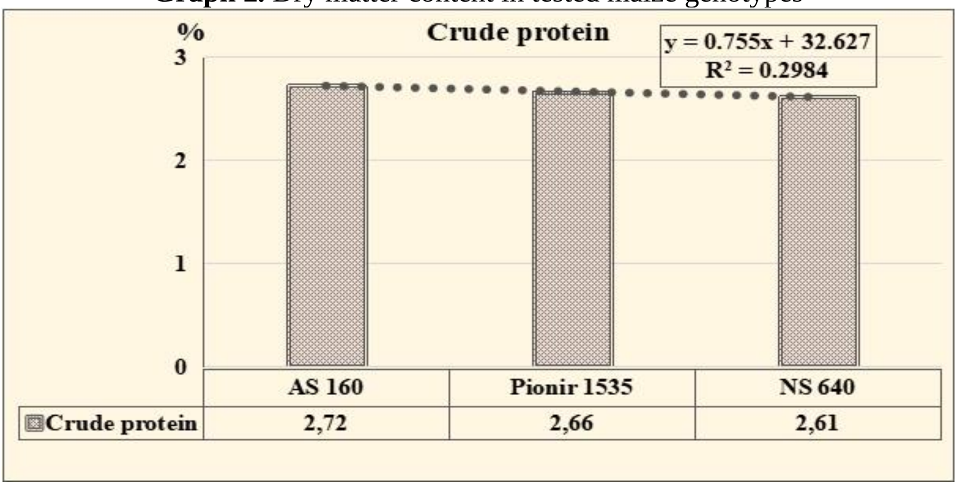
Silage maize is one of the most important forages in the world, and its yield and quality properties are critical parameters for livestock production and assessment of forage values. The qualitative characteristics of maize hybrids are determined by the plant's morphology and structure (Bertoia & Aulicino, 2014). Different hybrids have different levels of various maize plant components' digestibility. The average dry matter yield of silage maize was (19.98%) mgha^{-1}, and the average value of crude protein, ether extract, crude ash, crude fiber, acid detergent fiber, neutral detergent fiber, nitrogen-free extract, and relative feed value was 7.86%, 2.53%, 5.05%, 23.97%, 27.62%, 51.60%, 59.68%, and 131.17%, respectively. In general, its nutritive value decreased as its yield increased. Increasing planting density could increase the yield but inhibit the nutritive values, while increasing fertilization could benefit the nutritive values (Zhao et al., 2022).



Graph 1. Moisture content in tested maize genotypes



Graph 2. Dry matter content in tested maize genotypes



Graph 3. Crude protein content in tested maize genotypes

The yield components, such as the dry matter yield of the maize plant, were strongly influenced by genotype, according to the principal components. Future breeding strategies aimed at developing new, enhanced silage maize hybrids may find considerable value in our findings (Nikolić et al., 2022).

Maize grain yield is a complex trait and important indicator for assessing the value of maize genotypes in selection and breeding programs of maize of standard grain quality. Grain yield of maize and quality is a result of the combined effects of genotype - G, environment - E and GEI interaction. Since that GEI causes different reactions of maize hybrids in different environments, it is preferable to select and identify hybrids with high yield and quality potentials with wide adaptability and stability, more than to develop hybrids specially designed for certain agro-ecological environment. Genotypes with stable yield and quality tend to be more tolerant in stress conditions and more efficient in using available resources (Popović, 2010; Tabakovic et al., 2013; Babić et al., 2016; 2022; Popović et al., 2020; Ljubičić et al., 2023a; 2023b).

Our country has numerous maize hybrids for different purposes and high yield potential, so the main goal of producers should be to make greater use of their production capabilities. By applying more modern agrotechnical measures, such as optimal plant nutrition, better protection against weeds and crop irrigation, which will make maize production more profitable, because by increasing the total volume of production, we can provide the necessary amounts of grain and vegetative biomass for all the needs of the domestic food industry and livestock production (Janković et al., 2019). All surpluses should be offered on the world market, not only grains, but also numerous finished products. One of the important tasks is to change our traditional way of using grains as concentrated animal feed.

In order to more comprehensively use it in the nutrition of domestic animals, the area under silage maize should be increased as the main crop, and in irrigation systems as a secondary crop. For fodder production, it can be grown as a pure crop or in mixtures with legumes. Since there are a large number of early-maturing hybrids in our country, the production of silage maize should be expanded to hilly areas. The produced biomass would be used as bulk fodder fresh or silage (Ikanović et al., 2018). Producers' interest in silage maize grows from year to year thanks to hybrids from the stay green group that keep the above-ground biomass physiologically active even in the stages of grain maturation.

Conclusion

Applying more modern agrotechnical measures, such as optimal plant nutrition, better protection against weeds and crop irrigation, will make corn production more profitable, because by increasing the total volume of production, we can provide the necessary amounts of grain and vegetative biomass for all the needs of the domestic food industry and livestock production. Based on the present findings, it can be concluded that maize genotypes exhibit different responses in the environment.

Deficit in precipitation in the generative phase, resulting in lower quality parameters in the season of 2022. In this study, stable maize genotypes with high mean values for each trait were identified. Different hybrids have different levels of various maize plant components' quality.The genotype G3 (NS 6000) with higher dry matter than average mean, expressed the most stable reactions compared to all genotypes, which can determine it as outstanding high-quality in most environments and determine this genotype suitable for cultivation in diverse environments.

Climate is an important factor in maize production, adaptation measures, such as adequate production technology and choice of appropriate maize genotypes based on verified and confirmed data, are the most important in mitigating inappropriate weather conditions.

Acknowledgments

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TRAINING OF HORSES THROUGH NEGATIVE AND POSITIVE REINFORCEMENT

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Abstract

This paper aimed to present the current knowledge regarding the horse's perception of negative and positive reinforcement in training. Horses trained with positive reinforcement show fewer stress-related behaviors, fewer avoidance behaviors, and more signs associated with positive emotions compared to those trained with negative reinforcement. Although training horses with positive reinforcement is becoming more popular, there is still limited research on the potential long-term benefits in terms of stress, emotional state, and horse-human relationships. Ultimately, the outcome of the results is greatly influenced not only by the testing methods, but also by the testing approach, the horse and the horse's level of training.

Key words: Human-horse interaction, training, negative reinforcement, positive reinforcement.

Introduction

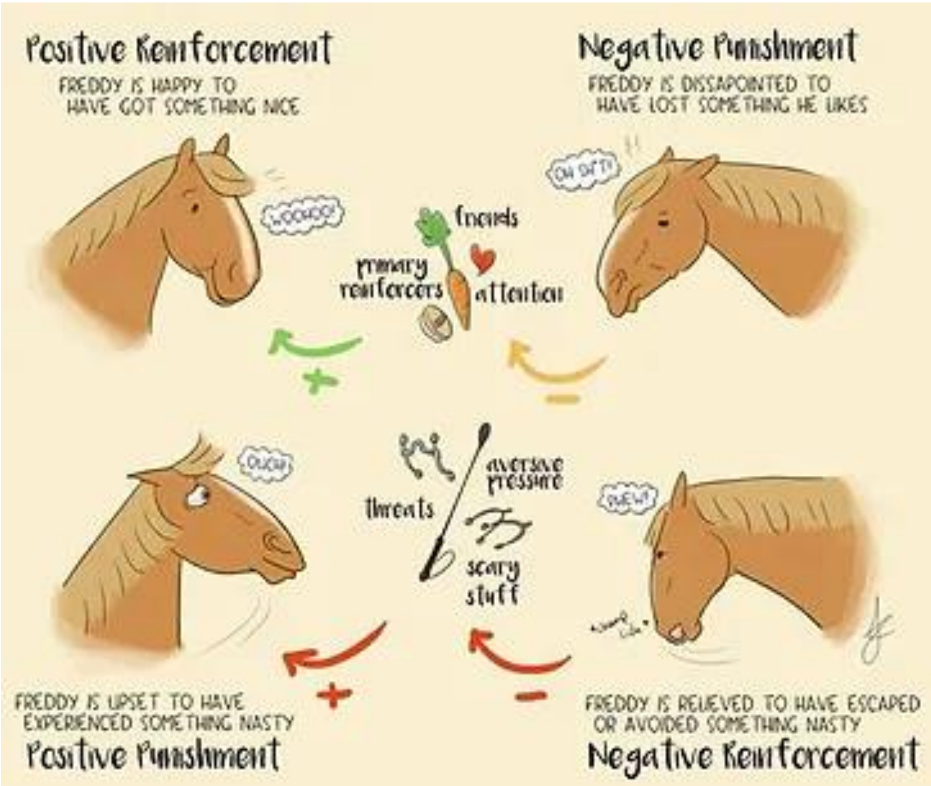
The transition of horses from transportation to sports, therapy, or companion animals requires a better understanding of how horses perceive and adapt to human interactions. Interaction between rider and horse is a key component when it comes to good riding (Eckardt and Witte, 2017). Therefore, today more and more scientists deal with negative and positive reinforcement.

Many studies support positive reinforcement as an effective method of training horses (Innes and McBride, 2008; Sankey et al., 2010a, 2010b; Hendriksen et al., 2011; Freymond et al., 2014; Fox and Belding, 2015; Dai et al., 2019; Larssen and Roth, 2022). Namely, the rider must have a perfect understanding of his horse. This ability can mostly be demonstrated by lightness and ease of the movements as well as by freedom and regularity of the paces. As a result, the horse becomes relaxed, flexible, and loose (Fédération Equestre Internationale, Martin et al., 2016, Wolframm et al., 2013).

Considering the importance of understanding the perception of human activities by horses, the paper aimed to present the current knowledge about the horse's perception of negative and positive reinforcement in training.

Reinforcement

Horses trained with positive reinforcement show a lower frequency of stress-related behavior, then a lower frequency of avoidance behavior, and more signs associated with positive emotions compared to those trained with negative reinforcement (Dai et al., 2019). According to Sankey et al., (2010a), negative reinforcement was associated with increased emotional state, as detected by measuring heart rate and observing behavior (head movements and laid ears). According to a study by Larssen and Roth (2022), horses trained with positive reinforcement have a more positive perception of people. Furthermore, the same authors found no measurable effects on emotional state or long-term stress levels.



Picture 1. Presentation of learning methods in horses (Fairhorsemanship, 2022)

Positive training is proposed to improve the horse-human relationship, because horses trained with positive reinforcement show increased contact-seeking behavior towards an unknown person (Sankey et al., 2010a, 2010b; Lundberg et al., 2020; Larssen and Roth, 2022), and have a more positive attitude towards their trainers (Freymond et al., 2014) compared to horses trained with negative reinforcement. Furthermore, reward-based training could improve the human-horse relationship (Larssen and Roth, 2022).

Cognitive abilities of horses

Cognitive ability is the way an animal perceives and understands the world around it (Starling et al., 2016). Knowledge of cognitive abilities will greatly facilitate perceptions of reinforcement. The study of cognitive abilities consists of the analysis of all the mechanisms that allow obtaining information (5 senses) about the outside world, processing this information, how the animal stores this information (memory), and how it can use this information in making decisions when faced with a problem or by the situation (intelligence).

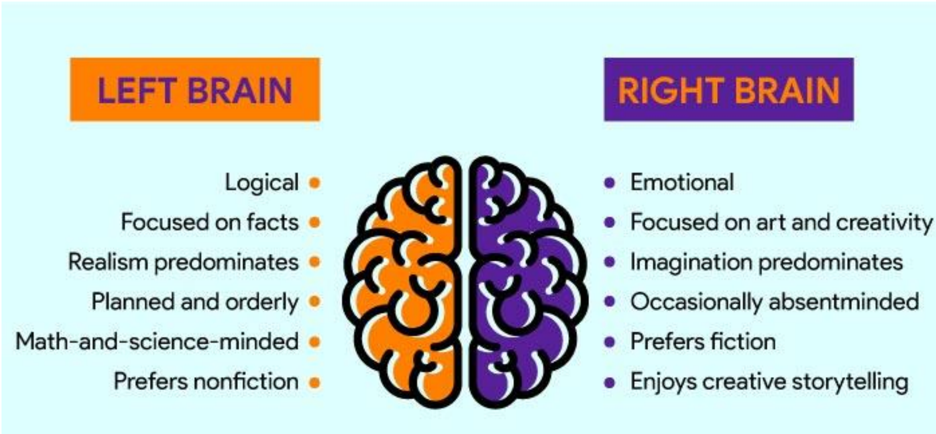
In behavioral science, intelligence can be recognized as the difference between the ability to observe and understand, and the willingness to obey human expectations is the ability to learn. By studying the cognitive abilities of horses, it provides a better understanding of how horses understand the world around them, and thus we can identify potential sources of stress. Horses' cognitive abilities are shaped by an evolutionary process, both by environmental challenges and complex social dynamics. Allowing the horse to experience variety and express curiosity gives us insight into how they feel in different situations.

Furthermore, learning and memory are closely related. Learning is a process of behavioral changes based on acquired knowledge and experience. Memory is the ability to retain and use what has been learned.

There are different ways how horses can learn. According to (Brubaker and Udell 2016) they include:

- Habituation - recognized when the animal stops responding to events and stimuli over time as it gets used to them;
- Hypersensitivity - when the intensity of an individual's response is increased;
- Operant conditioning - describes training using reward or punishment;
- Shaping - gradual building of behavior, step by step;
- Classical conditioning - signs and signals are used to initiate or induce behaviour.

The right hemisphere of the brain is responsible for reactive, emotional responses, such as fear or joy (Picture 2). An object or a person observes with the left eye and this information is processed in the right hemisphere. The situation is more emotional for the horse, while the information received by the right eye and projected to the left, rational hemisphere is analytically processed (Sankey et al., 2010a). In this study, horses treated with positive reinforcement did not show the presence of a gaze, while ponies trained with negative reinforcement showed a left-eye gaze bias towards the man approaching them. Left eye gaze was more often associated with fear-inducing situations, while right eye gaze was usually associated with more positive events.



Picture 2. Functions of the sides of the brain (MentalUP, 2023)

Learning ability is usually defined as the number of experiences that an individual need to retain something in relatively permanent memory. The ability to solve problems is defined as the ability to mentally overcome obstacles, compile and master various data into an accurate answer, or search for new ways to apply previously learned knowledge in learned situations. In humans and animals, these two abilities make up adaptive intelligence.

Research conducted in Japan (Tomonaga et al., 2015) tested memory and communication in horses. The researchers presented the horses with touch-screen televisions. They were taught various shapes and their meanings. They encouraged some shapes by showing the horses that they would get a tasty treat when a certain shape was presented to them. Furthermore, they then tested the horses to see if they could recognize the shapes, communicate their needs and remember which shapes allowed them to eat the treats. Horses learned quickly and easily discriminated shapes and used touchscreens to obtain treats (Tomonaga et al., 2015).

Furthermore, research conducted by Ringhofer and Yamamoto (2016) indicates that horses have an excellent power of communication. The testing was carried out on eight domesticated horses that showed that they will communicate their problems with humans. The researcher placed the carrot in a bucket in front of the horse, then placed the bucket in a place where only he could access it, not the horse. The horse then used visual and tactile communication methods to indicate to the researcher that it wanted a carrot.

In their daily routines, horses face new and sudden stimuli or objects that appear in their environment, which can cause them stressful reactions. Fear is a natural and useful reaction of the body. It protects the horse from seemingly life-threatening situations. Horses tend to react by avoiding or running away from an unfamiliar and potentially dangerous situation. Fear reactions protect the horse, but at the same time, they can be dangerous for people who are in direct contact with the frightened horse. Spooking is associated with 27% of horse accidents (Camargo et al., 2018). "*Spooking*" is defined as the fear of a horse, where the horse reacts suddenly, causing the rider to fall off the horse, with the rider unaware of what caused the horse to react. Horses that startle easily are not only more difficult to handle during various daily activities, but fear also affects their well-being and safety. Fear is the body's response to a potentially threatening situation (Golbidi et al., 2015). Behavioral indicators of stress include wide eyes, ears laid back, nostrils flared, head tossing, head held high, and trembling (Pearson et al., 2021). Fear is an innate and normal state, it is shaped or changed through appropriate processes of learning and adaptation. Furthermore, upbringing, training, and behavior have a strong influence on sensitivity and fear. Experienced horse trainers know that it is important to accustom young horses to new things in their environment. Christensen et al. (2010) used the desensitization method in their research, which showed a total of fewer frightened horses, and they needed less training to learn to calmly react to the stimulus test. All horses on the desensitization method eventually habituated to the test stimulus, while some horses on other methods did not (Christensen et al., 2010). Age has also been shown to influence reactivity. In the research conducted by Caviello et al. (2016) tested horses between the ages of two months and two years, and found that younger horses were more reactive.

Stress also affects cognitive abilities. A negative influence of fear on the learning performance of the task was discovered, which could be caused by excited animals being afraid and thus paying less attention to the task (Christensen et al, 2021). Horses can be exposed to short-term acute stress such as the sound of a plastic bag or a barking dog. Exposure to acute stress can cause various physiological reactions to stress (changes in heart rate, temperature, breathing rate) and changes in behavior (running away, hitting). Acute stress is not always bad and the reactions are generally beneficial and help the horse learn and adapt to its environment which increases survival. However, if the problem continues into chronic, long-term stress, it could negatively affect well-being (Ishizaka et al., 2017). The initial gathering of information about the emerging situation happens very quickly. The horse will then decide whether to investigate further or whether to avoid the situation. When a new situation occurs quickly, the horse's safety instincts may kick in, causing panic or fear as they reflexively try to move away from the potentially dangerous object. Most changes or new experiences do not cause panic attacks, although many horses are more prone to this behavior than others. Horses that are afraid are easily frightened, and if this affects their quality of life, it is important to work with them and encourage their curiosity in order to develop greater self-confidence.

Temperament is defined as a set of behavioral characteristics (called traits) that are stable over time and situations (Lansade et al., 2008). Five dimensions of temperament have been characterized in horses and can be measured by a series of behavioral tests:

- Emotionality: horse's reaction to sudden or new events;
- Sociability: how the horse tolerates separation from other horses;
- Level of activity;
- Sensory sensitivity: reaction to stimulation (tactile);
- Reactivity to people (Lansade et al., 2013).

Each of these dimensions can be measured and one or more tests are defined for them. The tests include the use of various auditory, visual, and tactile stimulations. The horse's emotionality is assessed during the unknown surface test, the unknown object test, and the suddenness test.

The suddenness test (or umbrella test, picture 3) reproduces what happens during a visual event. If the horse reacts strongly to this test, it is a sign of emotionality. Such horses are suitable for sport riding with experienced riders. Low-emotional horses are more suitable for novice riders and recreational riding. Such horses show curiosity towards a new object, are not afraid of it, and approach it. There is no such thing as a good or bad temperament, but one can define a type of temperament that is more suitable for a particular use. Timider, highly mobile horses with high tactile sensitivity can make excellent show-jumping horses. On the other hand, a beginner horse will have less tactile sensitivity, will be curious and willing to participate when touching new objects, and will move less when separated from other horses. Horses not only show individual differences concerning breed, age, and sex but also in terms of behavior patterns. It depends on the horse's temperament whether the horse considers the object or situation to be a potential threat or a beneficial experience. There is limited evidence that learning ability can be considered a single trait in animals due to variations in performance across different types of tasks (Shaw and Schmelz, 2017).

Picture 3. Subject (brown horse) during the umbrella test with its companion (white horse) (Ricci-Bonot, et al., 2021)

A reliable method for assessing stress levels

In order to understand how interactions, affect horses, it is necessary to reliably assess stress. Accurate evaluations of strength, speed, endurance and agility (mobility) of horses will certainly enable improved fitness and ability to work. Understanding the occurrence of fatigue during activities could enable the development and improvement of the biomechanical qualities of horses;

development and maintenance of horse motivation the physiological potential of the horse; reducing the risk of injury; and stabilization of heart function due to exertion (Rose and Evans, 1990; Clayton, 1991; Brineš et al., 1998; Röthing and Prohl, 2003; Voswinkel, 2009). Larssen and Roth (2022) report that they found no measurable effects of long-term stress levels.

Conclusion

Based on the analyzed studies, it can be pointed out that although training horses with positive reinforcement is becoming more and more popular, there is still limited research on the potential long-term benefits in terms of stress, emotional state, and horse-human relationship. Finally, the outcome of the results largely depends on the testing methods, rather than the testing approach, the horse, and the horse's level of training.

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EFFECT OF GROWTH BIOSTIMULATORS ON FLOWER AND SEED YIELD PARAMETERS OF *CALENDULA OFFICINALIS*

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Abstract

Calendula.officinalis is a medicinal plant species known for centuries and it is widely used in cooking, medicine and numerous processing industries. In an attempt to improve the productive properties of C. officinalis in pots, an experiment was conducted at the experimental field of the Institute for Medicinal Plants Research "Dr. Josif Pančić" Belgrade, Serbia. This work aimed to examine the influence of organic growth biostimulators on the flower and seed yield parameters of C. officinalis grown under semi-controlled conditions.
The experiment contained two treatments by priming C. officinalis seeds for 20 minutes, organic biostimulators (EkoBooster1 - E and Algo Fast - A) and one control treatment (K) in distilled water.
The results of the experiment showed that the yield parameters during the first four harvests were significantly better in the treatments with biostimulators, while in the later harvests the yield parameters were better in the control treatment. In contrast to the treatments with biostimulators (A) and (E), the yield of seeds per plant (9.2 and 8.9) was significantly better in the control treatment (K-12.8), while the percentage of germinated seeds did not differ significantly between treatments (A:91.3 %; E: 90.2%; K: 92.4%). The outcome of this study shows us that biostimulators have a positive effect on the parameters of marigold flower yield in the initial stages of harvest, while they did not have an excessive effect on seed yield.

Key words: Marigold, Germination, Priming, EkoBooster1, Algo Fast.

Introduction

Calendula officinalis, popularly known as marigold, belongs to the *Asteraceae* family, originating from southern Europe, and is grown as an annual plant species mainly for decorative and pharmaceutical purposes (Baciu et al., 2010). The use value of *C. officinalis* was noted as early as the 18th century, for the treatment of wounds, as a medicine for measles, against jaundice, red eyes and headaches (Page et al., 1998). The leaves and flowers, which are used in the pharmaceutical and food industry, have the highest utility value. Nowadays, it is mainly used for preparing teas, tinctures and infusions. According to the literature, tea is used as a means to remove rashes, to prevent inflammation of the mucous membrane, to wash the eyes, while tinctures are used to treat mental tension and insomnia, and infusions are used as an antiseptic and antifungal agent for wounds (Safdar et al., 2010; Boericke, 1998). In recent years, the seeds of *C. officinalis* have attracted great scientific interest because they represent a significant source of oil with unique properties. According to the literature, the oil content of *C. officinalis* seeds ranges from 5% (Angelini et al., 1997) to 22% (Dulf et al., 2013; Gesch et al., 2013). C. officinalis oil contains large amounts of linolenic acid, among which calendric acid is the most dominant. Marigold oils are used in various chemical industries to produce resins, varnishes, inks, paints and many coatings (Biermann et al., 2010). In addition, they are important in medicine because they are used due to the manifestation of anti-cancer effects, more precisely, previous in vitro research states that calendric acids can induce apoptosis in human monocytes, leukemia cells, colon cancer cells and choriocarcinoma (Suzuki et al., 2001; Li et al. al., 2013).

In earlier years, the need for medicinal plant species was met by collecting them from nature. However, the irrational exploitation and the increasing tendency for alternative medicine in the treatment of various diseases, there was a need for the cultivation of various medicinal plants both on a global level and within the Republic of Serbia. According to the literature, the most adequate and economical way to achieve appropriate performance in order to increase yields is the use of appropriate agrotechnical measures (appropriate varieties, optimal sowing time, plant density, etc.), (Mirzaei et al., 2016). According to Mirzaei et al., (2016), by applying appropriate agrotechnical measures, more precisely, by choosing a variety, appropriate treatment of seeds, soil, sowing date, nutrition, harvest time, the arbitrary potentials of *C. officinalis* can be greatly improved. Nowadays, establishing the production of *C. officinalis* is done by machine sowing of seeds in an open field at a depth of 3 cm and an inter-row distance of 50-60 cm. Sowing of seeds in the open field starts in spring, while under controlled conditions it can start at the end of winter. During the growing season, irrigation and nitrogen fertilization are applied as supplementary agrotechnical measures (Stepanović et al., 2011). The harvesting of *C. officinalis* flowers is done successively, starting in mid-June, when more than 2/3 of the plants have started to bloom, and lasts until the beginning of September (Kišgeci et al., 2010). According to Król et al. (2017), the optimal period for harvesting seeds is in the early stage of ripening, when 80% of the seeds have ripened. Research by Bertoni et al., (2006) indicates that flower and seed yield as well as their phytochemical composition largely depends on agroecological conditions, primarily on climate and soil. Other research by Paim et al., (2010) indicates that the phytochemical composition and yield parameters can be positively influenced by organic biostimulators. Namely, they are widely used as a pre-sowing seed treatment to promote germination and for faster and more advanced growth of other horticultural plant species (Gordanić et al., 2022; Parađikovic et al., 2017). Research by Rafiea et al., (2016), state that in *C. officinalis*, organic biostimulators have a great influence on growth and development. Also, the research of Mohamed et al., (2020), emphasize the positive outcome of biostimulators on plant height, number of branches per plant, plant weight, seed yield/plant, weight of 1000 seeds, content of chlorophyll a, b, carotenoids, N, P, K, carbohydrate content as well as on percentage of oil and fatty acids in the medicinal plant species *Salvia hispanica* L.

The aim of this study was to examine the influence of organic growth biostimulators on the yield of flowers and seeds of *C. officinalis* and at the same time to determine the germination percentage of the same seeds.

Material and methods

Plant material

To conduct the experiment, reproductive material (seeds) originating 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.

Treatments

In March 2022, an experimental trial was set up at the Institute for the Study of Medicinal Plants "Dr. Josif Pančić" in Belgrade and Pančevo. The experiment was designed so that it contained two treatments with organic growth biostimulators based on humic substances (EkoBooster1 - E) and based on seaweed extracts (Algofast - A), as well as one control treatment (K). The treatments were carried out by priming (submerging) the seeds according to the recommendation of the biostimulator manufacturer for 20 minutes, while in the control treatment, the seeds were primed in distilled water for the same time interval. According to the manufacturer's characteristics, EkoBooster1 is an organic fertilizer, biostimulator or bioregulator, a preparation intended for seed processing and strengthening the root system during plant rooting. It contains all the necessary nutrients and plant hormones needed for the early stage of plant development, primarily 2.8% organic matter, 14% nitrogen, 2% phosphorus, and 5% potassium. Accordingly, Algofast is a highly concentrated extract based on Ascophyllum nodosum algae, which contains potassium and nitrogen. The advantages of Algo fast are reflected in the active ingredients that include available plant hormones and useful trace elements (Fe, Zn, Cu, Mn, Ca, Mg, Na, S, etc.) which, in combination with nitrogen and especially potassium, make this preparation is a very useful biostimulator. After treatment, according to Mrđan et al., (2022) and Gordanić et al., (2023) seeds were sown in polystyrene containers with 40 holes, previously filled with the substrate "Cultivo I SF" (Gramoflor, Romania) with the following characteristics declared by the manufacturer: granulation: 0 - 5 mm; nutrient content: NPK 18:10:20+Mg+me in the amount of 1 kg/m3, slow-acting fertilizer: RADIGEN®-Jost GmbH in the amount of 50 g/m3; hydrogel in the amount of 1 kg/m3. One treated seed was placed in each container cell, and each treatment contained 4 containers (160 plants per treatment).

Plant production

After sowing, the containers are placed in a polyethylene tent (Grow Box), in which they are subjected to the following growing conditions: air humidity from 40 to 60%; air temperature from 20 °C to 25 °C, lighting regulation was performed 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) (Mrđan et al., 2022, Gordanić et al., 2023).

At the end of March 2022, with the appearance of the first true leaves, the containers were taken out of the polyethylene tent and occasionally brought outside in order for the seedlings to adapt to lower air temperatures, reduced relative humidity and natural light radiation for a period of 3 weeks as recommended by Mrđan et al., (2022). After that, 40 uniform plants were separated from each treatment and transplanted into plastic pots (ø 13 cm) previously filled with the same substrate (Cultivo I SF). Pots with seedlings were transferred to an unheated greenhouse, in 30% shade with an average daily temperature of 24±2 °C. The seedlings were watered using a drip system (Figure 1).

At the beginning of April, the pots were taken out of the greenhouse to the experimental field of the Institute for the Study of Medicinal Plants "Dr J. Pančić" in Pančevo, South Banat, Serbia (77 masl; 44°52'18.9” N 20°42' 09.0” E) . The pots are placed on a black "agro textile" film that acts as a mulch. At the same time, the pots were irrigated using drippers with a flow rate of 1 l/h for each plant. Irrigation was carried out daily for 10 minutes (Figure 1). Meteorological data during the experiment were collected from a measuring device (Data logger), previously placed not far from the experimental field (table 1).

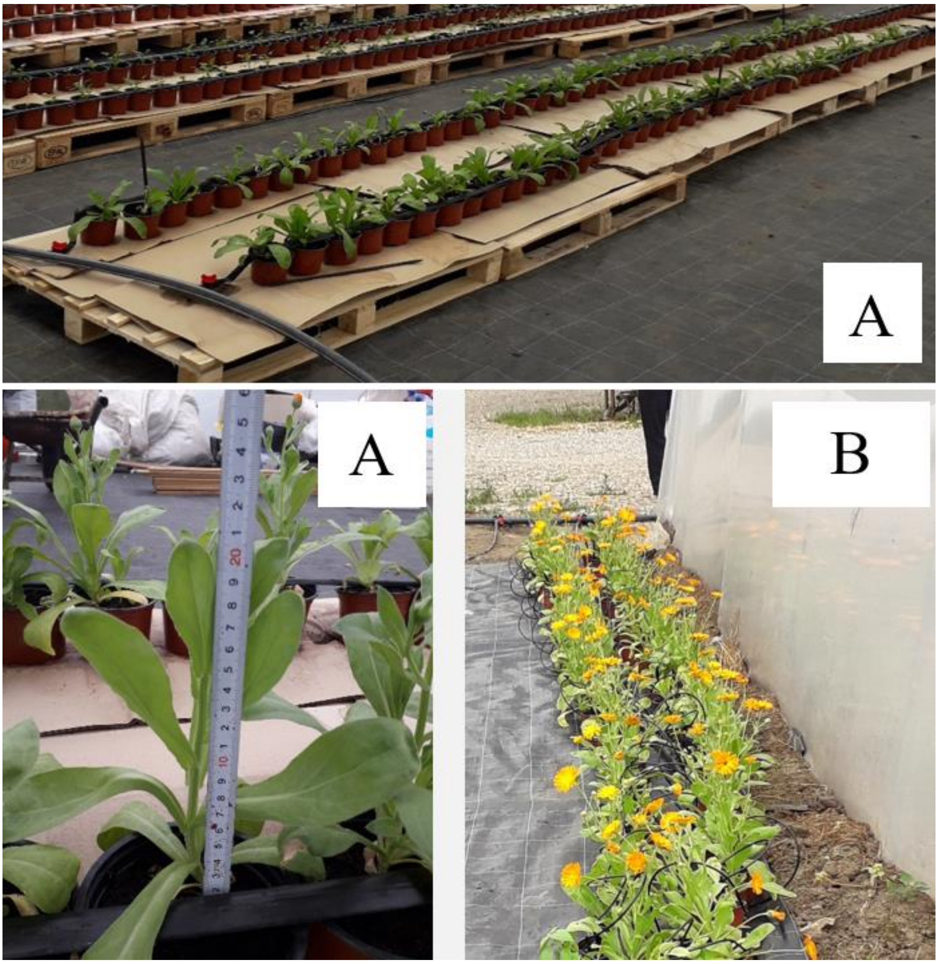
Table 1. Meteorological parameters during the experiment (April-Avgust 2022)

Climatic parameters	April	May	June	July	August
Temperature (°C)	11.5	20.1	24.5	25.7	24.9
Precipitation (mm)	57.2	34.9	23.5	72.0	72.0

Harvest and statistical analysis

Flower harvesting was done at the moment when more than 2/3 of the plants were in flower (at the beginning of June), and it was carried out successively (seven times), each time after re-education of flowers. After harvesting the flowers from each plant individually, the number of flowers per plant was recorded and the weight of their fresh and dry mass after drying was measured (g/plant). Harvesting of *C. officinalis* flowers in this study lasted until the end of the physiological cycle in the pot (end of August). At the end of the seventh harvest, and at the end of the physiological cycle when 80% of the seeds have matured according to Król et al. (2017), flower heads with educational seeds were collected from each treatment. After collection, the number of seeds per plant, the weight of 100 seeds per treatment, and the germination of seeds sampled from each treatment were measured. Until the beginning of the experiment, the collected seeds were stored at room temperature (20-30 °C). Laboratory germination was performed on the collected seeds in Petri dishes (4 x 100 seeds), on filter paper that was previously moistened and placed in two layers (ISTA, 2006).

The obtained results were statistically processed using one-factor analysis of variance (ANOVA), comparing mean values using Duncan's test ($p<0.05$) using SPSS software.



Picture 1. A-growing in a greenhouse; B-cultivation in the open field

Results and discussion

The obtained results of this research are presented tabularly (Table 2-8).

Table 2. Flower yield parameters of the first harvest

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	16.76±0.06a	14.04±0.02a	2.08±0.01a
E	14.10±0.09b	12.06±0.03b	1.81±0.05b
K	8.36±0.04c	8.97±0.01c	1.39±0.04c

** A-Treatment in Algofast solution; E-Treatment in EkoBooster1 solution; K- control treatment. Results are expressed as mean ± SD (n=3). Mean values in the table in the same column marked with the same letters do not differ statistically significantly (p < 0.05).*

According to the results of the previous table, it can be seen that the treatment with Algofast (A) in the first harvest had the most dominant effect on the number of flowers, and also on the weight of fresh and dry flowers. Compared to the control treatment (K), a similar effect, but a slightly higher number of flowers as fresh and dry flower weight was obtained in the treatment with EkoBooster1 (E) (Table 2).

Table 3. Flower yield parameters of the second harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	14.76±0.10a	14.04±0.06a	2.28±0.09a
E	12.10±0.09b	11.86±0.08b	2.01±0.03b
K	9.96±0.07c	8.65±0.06c	1.43±0.04c

** A-Treatment in Algofast solution; E-Treatment in EkoBooster1 solution; K- control treatment. Results are expressed as mean ± SD (n=3). Mean values in the table in the same column marked with the same letters do not differ statistically significantly (p < 0.05).*

In the second harvest, the results show that the Algofast treatment was more successful than the other treatments. Namely, the highest number of fresh flowers per plant as well as the weight of fresh and dry flowers per plant was obtained with the use of Algofast (A), which is statistically significantly higher than with the other treatments. A similar effect, but slightly lower results, was achieved by applying EkoBooster1 (E), while the smallest effect was achieved in the control treatment (K) (Table 3).

Table 4. Flower yield parameters of the third harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	14.26±0.01a	14.94±0.09a	2.68±0.04a
E	13.10±0.04a	13.86±0.09a	2.56±0.01a
K	10.56±0.06b	9.55±0.03b	1.53±0.02b

** A-Treatment in Algofast solution; E-Treatment in EkoBooster1 solution; K- control treatment. Results are expressed as mean ± SD (n=3). Mean values in the table in the same column marked with the same letters do not differ statistically significantly (p < 0.05).*

The results of the third harvest show that the highest yield parameters were achieved in treatments with biostimulators and that there is no statistically significant difference between them. However, there is a statistically significant difference in treatments with biostimulators compared to the control treatment, in which slightly lower values of yield parameters were obtained (Table 4).

Table 5. Flower yield parameters of the fourth harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	16.21±0.09a	16.25±0.03a	2.91±0.05a
E	15.85±0.02a	16.11±0.03a	2.81±0.04a
K	11.43±0.03b	10.21±0.06b	1.63±0.03b

** A-Treatment in Algofast solution; E-Treatment in EkoBooster1 solution; K- control treatment. Results are expressed as mean ± SD (n=3). Mean values in the table in the same column marked with the same letters do not differ statistically significantly (p < 0.05).*

According to the results, the outcome of the fourth harvest was similar to the previous one. Namely, the highest yield parameters achieved in the treatments with biostimulators and between them show no statistically significant difference, while the lower values of the yield parameters were achieved in the control (K) (Table 5).

Table 6. Flower yield parameters of the fifth harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	13.95±0.26a	12.43±0.09a	2.61±0.06a
E	14.67±0.16a	12.41±0.16a	2.59±0.07a
K	14.43±0.09a	11.93±0.06a	2.57±0.05a

* *A-Tretman u rastvoru Algofasta; E-Tretman u rastvoru EkoBooster1; K- kontrolni tretman. Rezultati su izraženi kao srednja vrednost ± SD (n=3). Srednje vrednosti u tabeli u istoj koloni označene istim slovima statistički značajno se ne razlikuju (p < 0,05).*

The outcome of the fifth harvest is significantly different from the others. Namely, a similar result of all yield parameters was achieved in all treatments, more precisely, there are no statistically significant differences between treatments (Table 6).

Table 7. Flower yield parameters of the sixth harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	11.95±0.11a	11.23±0.05a	2.41±0.10a
E	11.67±0.13a	11.61±0.06a	2.38±0.09a
K	12.01±0.09a	10.93±0.09a	2.35±0.16a

* *A-Tretman u rastvoru Algofasta; E-Tretman u rastvoru EkoBooster1; K- kontrolni tretman. Rezultati su izraženi kao srednja vrednost ± SD (n=3). Srednje vrednosti u tabeli u istoj koloni označene istim slovima statistički značajno se ne razlikuju (p < 0,05).*

The outcome of the sixth harvest according to the obtained result is similar to the previous one.For the most part, there are no statistically significant differences between treatments (Table 7).

Table 8. Flower yield parameters of the sixth harvest:

New treatment	Number of fresh flowers per plant	Weight of fresh flowers(g/plant)	Weight of dry flowers(g/plant)
A	10.84±0.10b	9.83±0.17b	1.91±0.09b
E	10.73±0.12b	9.91±0.09b	1.87±0.08b
K	12.35±0.16a	11.87±0.14a	2.34±0.13a

* *A-Tretman u rastvoru Algofasta; E-Tretman u rastvoru EkoBooster1; K- kontrolni tretman. Rezultati su izraženi kao srednja vrednost ± SD (n=3). Srednje vrednosti u tabeli u istoj koloni označene istim slovima statistički značajno se ne razlikuju (p < 0,05).*

In the case of the last, seventh harvest, the result is significantly different than in the others. More precisely, in the case of treatment with biostimulators, there was no mutual difference, while the control treatment proved significantly more dominant in all tested yield parameters compared to the others (Table 8).

Table 9. Marigold seed yield parameters:

New treatment	Number of seeds per plant	Germination%
A	9.2±0.12b	91.3±0.10a
E	8.9±0.18b	90.2±0.16a
K	12.8±0.15a	92.4±0.09a

** A-Tretman u rastvoru Algofasta; E-Tretman u rastvoru EkoBooster1; K- kontrolni tretman. Rezultati su izraženi kao srednja vrednost ± SD (n=3). Srednje vrednosti u tabeli u istoj koloni označene istim slovima statistički značajno se ne razlikuju (p < 0,05).*

Between treatments with biostimulators, there was no mutual difference in seed yield per plant, but the control treatment was significantly more dominant than the other treatments. Statistical analysis did not show a significant difference in the germination percentage of the tested treatments (Table 9).

Based on meteorological data recorded during the research, it can be said that precipitation was unevenly distributed during the growing season (Table 1). Namely, the excessive amount of precipitation and optimal temperature in July and August extended the period of flowering and ripening of seeds, which had a positive effect on the number of harvests.

In this work, it was shown how the seeds primed with organic growth biostimulators had the most dominant effect on the yield parameters of the *C. officinalis* flower during the first four harvests. A similar effect was achieved in the research of Rafiea et al., (2016), where it is pointed out that biostimulators have a dominant influence on the growth, development and yield of this plant species. However, there were significant differences between treatments with biostimulators. According to the literature, this outcome is associated with the different chemical composition of biostimulators (Wozniak et al., 2020). Considering that biostimulators based on humic substances (EkoBooster1) and seaweed extracts (Algo Fasta) were used, it is assumed that this is the main cause of mutual variability. By comparing the efficiency of these two biostimulators, it can be said that the biostimulator based on seaweed extracts (Algo Fast) exerted a more dominant influence on the first two harvests compared to EkoBooster1 or the extract of humic substances. In that case, we assume that Algo Fast had a better effect due to its greater content of chemical compounds, and this is confirmed and explained in more detail by research (Hines et al., 2021). According to the literature Moravčević et al., (2019), extracts of seaweed Ascophyllum spp., contribute to the promotion of faster plant growth because they contain polysaccharides laminarin, alginates, carrageenans, N-containing sterols, betanin, hormones, micro and macro elements, which probably influenced the positive outcome of this research during the first few harvest.

However, during the fifth and sixth harvest, yield parameters were similar in all treatments, and during the seventh, they were more dominant in the control treatment. A similar effect in examining the influence of biostimulators in medicinal plant species was achieved in the research of Gordanić et al., (2022). Namely, research indicates a more dominant influence of biostimulators during the initial stages and somewhat weaker during the later stages. According to the literature, biostimulators activate several physiological processes that enhance nutrient uptake and thus rapidly stimulate plant development (Moravčević et al., 2019). Considering the use of a uniform commercial substrate without any additional feeding during the experiment, we assume that there was an excessive consumption of nutrients during the first harvests and that this caused the dominance of the control treatment in the later harvests. Accordingly, according to Abou Dahab et al., (2006), plants treated with biostimulators have a faster development, and due to a faster metabolism, they synthesize more amino acids and therefore have a greater need for nutrients because there is a pronounced synergism between them. Other research by Halpern et al., (2015), indicate how some biostimulators can affect the reduction of nutrient consumption, which was probably not the case with the examined biostimulators, plant species and production method. we can point out that the variability of the obtained seed yields is partially in agreement with the yields obtained by Król et al., (2016). Based on the previous findings, we assume that the nutrient imbalance caused different seed yields in the treatments, with the control treatment being the most productive. However, the percentage of germinated seeds among treatments was very similar, which is probably attributable to the similar concentration of nutrients in the growing substrate during seed maturation.

Conclusion

With this research, we can conclude that organic biostimulators can have a positive effect on *C. officinalis* flower yield parameters, which is not the same case with seed yield. Organic biostimulators had the greatest impact in the first harvests, so their use can be recommended in future production.

Considering this research, it can also be said that when applying biostimulators, the optimal supplement should be determined so that the plant properly completes its physiological cycle. Taking into account that *C. officinalis* is known for its secondary metabolites, carriers of its medicinal properties, further study should be focused on the influence of organic biostimulators on the phytochemical composition of the obtained yields.

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POTENTIALS FOR THE DEVELOPMENT OF VITICULTURE AND WINEMAKING IN THE REPUBLIC OF SERBIA

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Abstract

The aim and subject of this research are the potentials for the development of viticulture and winemaking in Serbia, with a focus on improving the current state of wine exports from Serbia and exploring the possibilities of wine tourism development, especially in rural areas where the highest number of small wineries are present. The research period spans from 2018 to 2022.
The primary sources used in this study were obtained from the statistical database of the Statistical Office of the Republic of Serbia. The research is based on the so-called "desk research" method, as well as the utilzation of comparative research methods. The authors identify key issuses and provide suggestions for necessary measures that will contribute to increasing wine production volumes, enhancing the export of high-quality wines, and fostering wine tourism in Serbia through the promotion of rural environments.

Key words: Wine export, wine tourism, small wineries.

Introduction

Serbia has significant potentials for exporting produced wines, given the large number of multilateral and bilateral agreements that establish specific levels of customs protection in trade. The most significant trade agreements for Serbia include those with countries in the region of Southeast Europe (CEFTA), the European Union, the Russian Federation, Belarus, Kazakhstan, and Turkey. To utilize the existing potentilas in wine production, it is necessary to prevent a constant decline in total vineyard areas and to establish new vineyards with modern assortments aligned with contemporary production trends. Besides improving the conditions of the existing wine export from Serbia, investing in wine tourism is also crucial. Small wineries, which produce relatively small quantities of wine, are mostly oriented towards local retail or exports due to limited quantities. They are primarily focused on the local market, i.e., selling wine directly from the wineries, rather than engaging in wine tourism. Wine tourism is closely related to rural landscapes, as they contain the largest vineyard areas and wineries. Rural settings and lifestyle are essential elements in attracting and promoting wine tourism.

The aim and the objective of this research is to expolre how to leverage the existing potentials for the development of viticulture and winemaking that Serbia possesses in abundance, primarily due to favorable natural conditions. By doing so, it would ensure the production of high-quality wines made from grapes produced in Serbia, which could be successfuly exported, and it would also facilitate the development of wine tourism by attracting domestic and foreign tourists.

During the research, the statistical database of the Statistical Office of the Republic of Serbia was used. The “desk research” method and comparative methods were employed.

Results of the research with discussion

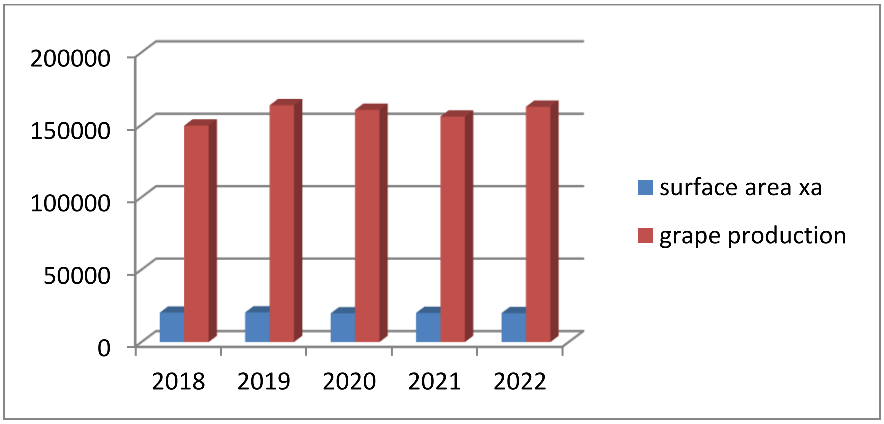
Potentials for Development conditions for wine export from Serbia

Serbia has significant potential and provides an excellent climate for viticulture, possibly the best in the Balkans, producing grapes with an ideal balance of acidity and sugars. Some parts of Serbia are influenced by a mid Mediterranean climate. The climate is characterized by a good light regime, which, along with temperatures, is crucial for obraining sufficient extract for grape production, with a partially favorable distribution during vegetation, which can be compensated by a good irrigation system (Vlahovic et al., 2017).

According to Tarailo and Vuksanovic (2021), tje agroecological conditions in Serbia are favorable for cultivating numerous table and wine grape varieties, ranging from the earliest to the latest ripening periods. The produced grapes ensure very good quality, both for the market and high-quality wine production. However, Serbian viticuture is still characteriyed by significant vineyard areas in the individual ownership sector. These vineyards have unfavorable age structure and are dominated by extensive cultivation forms, unfavorable varieties with low yield capacity for agricultural practices (Jaksic, 2019).

Today, Serbia is classified as a significant wine importer, although it was once a major wine producer for its own population and for th erepublics of the former Yugoslavia, as wellas a notable wine exporter. Currently the largest quantities of wine from Serbia are exported to the Russian Federation and CEFTA countries, including Bosnia and Herzegovina and Montenegro. To change the existing situation and leverage the potentials Serbia possesses, it is necessary to prevent further declines in vineyard areas and facilitate the stablishment of new, modern plantations resistant to diseases and pests, ensuring good wine quality.

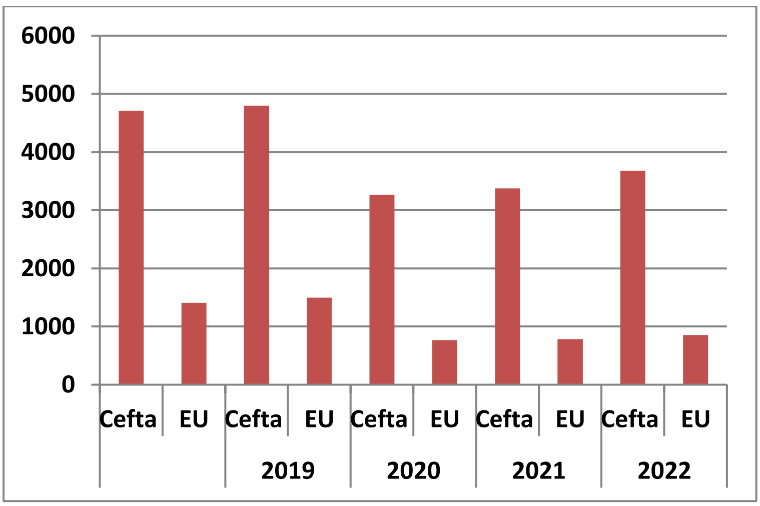
However, besides the crucial quality aspect for wine exports, particularly to European countries, it is also essential to increase the quantity of produced wine to meet the demand of both domestic and foreign markets. Despite favorable natural conditions for grapewine success and wine production in Serbia, the full utilization of these conditions is yet to be achieved, as evidenced by the declining vineyard areas observed in the observed five-year period.



Graph 1. Vineyard areas and grape production in the Republic of Serbia

Source: Statistical database of the Republic of Serbia

To improve wine export in the next period, from the grapes produced in Serbia, it is necessary to use potentilas better. The largest amounts of areas under the vineyards are owned by individuals, with dominant extensive cultivation forms , unfavorable old structure and small capacity of a genus. So, it is necessary to modernize existing sortment, by implementin sorts that are resistant to diseases and pests on the high level. On Graph 1 areas under the vineyard are showed and grapes production in observed five-year period. Serbia is the country that wishes to become a part of the European Union, where the grape and wine producer producers are more developed and more competitive by the price, and our sector of viticulture and winemaking is not still ready for equal participation on the such a big and important market.



Graph 2. Wine export from the Republic of Serbia

Source: Statistical database of the Republic of Serbia

The export structure of wine indicates the need for better branding of Serbia wines to increase their recognition in the market. Currently, in Serbia, family-owned vineyards and wineries in rural areas predominate, cultivating various grape varieties, and quality wines are often produced (Jovanovic et al., 2015). The data showed on the Graph 2 tells us that the largest amounts are exported to the market of CEFTA countries, primarily to Bosnia and Herzegovina and Montenegro, but also to the market of Russian Federation, and if we speak about the market of the European Union we export less amounts. On the tabel 1 SWOT analysis will be showed of the export chances from the market of the Republic of Serbia.

Table 1. SWOT analysis of wine export from the market of the Republic of Serbia

Strenghts	**Weaknesses**
Favorable agro-ecological conditions for grapes production	Extensive production and fragmentation of plots
Tradition in the production of high-quality wine	Weak assosiation of grapes and wine producer
The existence of certain incentives	Varying in the quality and number of grapes and wine
Favorable international agreements	Insufficiently developed grapes and wine market
	Lack of financia asset
	Predominant representation of small producers of grapes and wine
Chances	**Threats**
Enlarging of the export by producing grapes and wine more	Insufficient promotion of domestic wines and designation of geographical origin
Access to new wine markets	Higher level of state and EU incentive in the countries that are the main exporters of wine to the Serbian market
Enlarging wine production with geographical origin	Lack of conscience about the importance of marketing and wine promotion, which would enlarge the export
	Danger of small grapes and wine producers, which are imported from the market of Northern Macedonia

Source: Authors

Needs for the Development of wine tourism in Serbia

Special attention in Serbia is dedicated to rural tourism. The Republic of Serbia has numerous opportunities for the development of wine tourism, which have not been sufficiently stimulated so far. Wine tourism can be a vital business for many small wineries, offering advantages such as increased profit from the direct wine sales to consumers (Dećanski and Puzić, 2010).

According to Jovanovic et al., 2015, the presence of wineries in the tourist offer is insufficient and spoaradically developed, lacking a clear strategy at both the national and local levels. It is necessary to encourage their inclusion in tourism flows, primarily thorough the development of wine route. By enriching the hospitality content in wineries, prerequisites for successful development are fulfilled, not only in wine tourism but also in agrotourism, as tourists could experience firsthand the vineyard life.

The development of wine tourism is particularly significant for small wineries that lack the capacity for wine exorts. These wineries, which are predominant in Serbia, are oriented towards the local market, focusing on wine sales from wineries and local tourism. The SWOT analysis of the needs for the development of wine tourism in Serbia will be presented in Tabel 2.

Table 2. SWOT analysis of development f the wine tourism in the Republic of Serbia

Strenghts	**Weaknesses**
Greater volume of sales	insufficient involvement of the state in small wineries
Higher income	unrecognizability of importance of the wine tourism
Direct meeting with customes	expressed migration village - city
Brand making	poor purchasing power of the population
Development of positive image of destinations/rural areas	underdeveloped wine drinking culture in Serbia
Chances	**Threats**
Development of rural areas in Serbia and their recognition	adverse wine sales in small winery
Keeping youth in rural areas by employing	Capital lacks
Possibility that Serbia is recognized as wine country again	the uncertainty of starting wine tourism
Increasing profits in tourism on the state level	

Source: Authors

Wine tourism, as well as the business activity, may introduce essential business for small wineries. The significant number of recently established small wineries sell most of their wine “at the cellar door”. The development of wine tourism in a region creates numerous benefits, including increased sales and profits, visit education, improved connections with wine traders, product testing, and a rise in the number of visitors and prodeucers. It also contributes to the development of other sectors, rural employment, preservation of local traditions anf ways of life, and environmental protection. One of the successful ways to present wine tourism is through wine routes. Wine routes are a special form of wine sales, comprising natural beauty, tradition, and the uniqueness of the vineyard area. The advantages of wine routes are manifold, as they enable each winemaker to sell wine and products directly from their estate or cellar, facilitate new employment oppertunities, and encourage full engagement of rural people in preserving and reviving the original environment and traditional heritage in harmony with sustainable tourism development (Vlahovic et al., 2015).

According to Vlahovic, (2015) wine tourism represents one of the most crucial aspects of rural tourism. Its development brings numerous benefits to rural destinations at both individual and collective levels, including increased tourist's numbers, higher wine sales in wineries, and greater income. Serbia has significant potential for the development of viticulture and winemaking, stemming from agroecological conditions, traditions, the interest in wine production among family farms, and the existing of various multilateral and bilateral agreements that could boost wine export from the Serbian market. The conditions for wine tourism development will facilitate the placement of wine produced by small wineries unable to export their wine due to limited quantitie

Conclusion and Recommendations

Republic of Serbia has numerous advantages for grape and wine production, which it can better utilize in the future to increase exports and promote the tourism of small wineries. Currently, the relevant export markets for Serian wine are the countries of CEFTA and the Russian Federation. However, in order to increase exports in the future, the country must work on expanding existing vineyard areas by introducing high-quality varieties resistant to diseases and pests, which also yield large quantities of wine. Additinally, as Serbia prepares to enter the EU, it needs to focus on increasing wine exports to EU member states.

Direct benefits of wine tourism include higher sales prices, increased profits from wine sales in wineries, visitor education of potential wine consumers, improved connections with wine distributors, and other advantages. It is important to consider that the development of wine tourism depends not only on wine producers themselves but also on the state's global policies.

In recent years, atttention has been given to the development of viticulture and winemaking in Serbia, but it remains insufficient, particularly due to the country's preparations for the EU accession.

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ACQUISITION OF AGRICULTURAL LAND THROUGH LEASE AND ACCOMPANYING PROBLEMS

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Abstract

The share of leased land on agricultural farms has been increasing in recent years. With growing demand, rental prices are rising and there is constant interest in agricultural land.
The aim of the paper is to point out the problems of tenants of agricultural land, from searching for land for lease, to getting information about the offer of land, to terminating the contract, but also to propose appropriate solutions to the problem.
Quantitative and qualitative analysis was used in the paper, and the data was obtained from scientific and professional literature and a survey questionnaire conducted on agricultural farms in the Zapadnobački District of AP Vojvodina.
The results show that the share of leased land on farms in Zapadnobački District is relatively high, and leasing has an advantage over land purchase. When asked how to find agricultural land for rent, 79.2% of respondents stated that the landowners offered them the land themselves. Lessors are the state, legal entities, other farms, and the largest share of leased land is owned by natural persons. 70.8% of lease contracts are concluded in writing. The lease price is the most important element of the contract, and the time period, distance from the land, etc. are also important. Generally, a term of at least 3 years is agreed upon. 3/4 of tenants pay a slightly higher rental price every year. Problems related to the termination of the lease contract were also identified, where 45.8% of respondents determined that the lessor wants to terminate the contract prematurely, although the reasons are not always justified. The rent range for land ranges from €100 to €450 with an upward trend, which is a key problem. In addition, non-transparent bidding, early cancellation of contracts, lack of land for lease, are problems faced by tenants. Tenants could take more measures to keep the contract in force, and it is certainly recommended to do business with landowners, who have a good reputation.

Key words: Lease agreement, agricultural land, tenant problems.

Introduction

Land is a limited resource and in parallel with the growth of its value, it becomes a very good investment (Ramamurthy et al., 2017). In addition to other buyers, agricultural entities (individual farms, companies and cooperatives) are also interested in the land. Farmers, when expanding production capacity, prefer to invest money in technology and equipment, rather than in the purchase of land (Dube and Guveya, 2013).

Land leasing has become a common business practice for local farms. The share of leased land on agricultural farms is increasing from year to year. As the demand for land increases, rental prices rise and there is constant interest in agricultural land. Land leasing is often accompanied by problems. Problems arise when finding agricultural land for lease, concluding a lease agreement and later using the land due to different understanding of the contractual provisions (Adenuga et al., 2021).

AP Vojvodina is known for agricultural production with its fertile and large black earth fields and farms with a long tradition of production. While real estate prices in rural areas of AP Vojvodina are quite low, average rental prices and market prices of agricultural land are high.

Literature review

Agricultural land is that which is used for agricultural production, as well as land that can be used for the production of cultural plants. The Law on Agricultural Land ("Sl. glasnik RS", 62/2006, 65/2008, 41/2009, 112/2015, 80/2017 i 95/2018) classifies agricultural land into: arable land, gardens, orchards, vineyards, meadows, pastures, ponds, reeds and marshes.

Agricultural land is divided according to the form of ownership into:

1. *land in private ownership;*
2. *cooperative or land owned by legal entities;*
3. *leased land.*

As the demand for land grew, so did rental prices. According to the Survey conducted by the Republic Statistical Office in 2018, the area of leased agricultural land in the Republic of Serbia was 754,037 ha (RZS, 2018). If we compare this data with the year 2012 (610,136 ha), the area of leased land increased by 23.6% (Ševarlić, 2015). 10 years ago, the share of leased land was 12.54%, while in 2018 this share was 15.50%.

While most of the agricultural land of small farms is in their own ownership, the share of leased land is significant in the case of larger farms. It is estimated that farms with holdings above 100 ha cultivate only about 30% of their own land, and the rest is leased land.

The share of leased land on agricultural farms is increasing. This is due to the fact that the demand for agricultural products is growing, which leads to the need to expand production capacities. Agricultural farms prefer to invest in new technology, rather than in the purchase of land (Ciaian et al., 2012b; Dube and Guveya, 2013).

Buying and leasing land plays a big role for farmers, who want to be productive and own little land. However, a distinction must be made between buying and renting. Owned land can be sold, rented, and, if necessary, used as a mortgage. The following circumstances speak in favor of the lease (Swinnen et al., 2006):

- The possibility of land lease always exists;
- Since land lease does not require so much money and does not threaten liquidity, more capital remains for other investments;
- The land is in the hands of more efficient users than the owner. If you are not able to take care of the land, then the solution is to lease it;
- Leasing land is a good option for people who start farming.

However, the orientation of farms towards land lease is not an optimal strategy. If you are not the owner of the land, there is no business stability. Problems can arise, because you cannot take out a loan, i.e. provide adequate collateral. Leases, which are temporary in nature, do not provide sufficient incentives for effective investment in agriculture.

In several European countries, governments have passed laws to ensure that the minimum lease length is several years. In addition, lease length regulations are often accompanied by regulations that force landowners to compensate tenants for investments that improve the productivity of the land. Other rights are also granted, such as the tenant's right of first refusal (Swinnen et al., 2006). If there is a tenant on the agricultural land, he has the obligation to take care of the land ("Sl. glasnik RS", 62/2006, 65/2008, 41/2009, 112/2015, 80/2017, 95/2018). According to the provisions of the Law on the Basics of Property Relations ("Sl. list SFRJ", 6/80, 36/90, "Sl. list SRJ", 29/96, "Sl. glasnik RS", 115/2005), as well as the Law on Real Estate Transactions ("Sl. glasnik RS", 93/2014, 121/2014, 6/2015) the owner who intends to sell the agricultural land is obliged to offer it to the owner of the neighboring land beforehand. Furthermore, the right of pre-emption is valid for a third party, if it is registered in the land register. The problem is that states over-regulate the conclusion of leases, thereby eliminating the flexibility that was originally a positive aspect of leases (Ciaian et al., 2012a).

The owners of the land must do something with it, if they do not cultivate it. They have the option to sell it, lease it or assign it for free use. Agricultural farms have to decide whether to buy or lease land in order to increase productivity (Kuzman and Prodanović, 2017).

Finding land to lease should not be a problem, as most land resources have owners. Ways to find agricultural land for rent are (Learmonth, 2011):

- the owner of the land comes to offer the land for lease;
- a person who wants to lease land inquires;
- search for a plot and its owner via the Internet;
- use the help of real estate agencies;
- participate in the public auction for leasing state land.

The most favorable option for agricultural holdings would be for the owners to offer agricultural land for lease. If it is possible to achieve a favorable price, then you should consider auctioning state land. The most expensive would be to hire real estate agents to find land for lease.

According to data from the Agricultural Land Administration, the total area of state-owned agricultural land on October 31, 2021 was 805,795 ha, of which 397,111 ha are exempt from leasing and use (https://upz.minpolj.gov.rs/sadrzaj/, 02.06.2023).

The average fee paid for state land was €183.6/ha in 2020. However, in almost all local governments of AP Vojvodina, average prices are significantly higher and reach an incredible €750/ha (Poljoprivreda info..., 2023). Also, auctions for the lease of state arable land are one of the forms of corruption.

When a farmer finds land for lease, he should agree terms with the lessor, that is, conclude a lease agreement, which determines the rights and obligations of both parties. "With the lease agreement, one contracting party (the lessor) undertakes to hand over a certain non-consumable thing to the other contracting party (the lessee) for use, and the lessee undertakes to pay a certain fee for it and to return the same thing after a certain period of time" ("Sl. list SFRJ", 29/78, 39/85, 45/89 - odluka USJ 57/89, "Sl. list SRJ", 31/93, "Sl. list SCG", 1/2003 - Ustavna povelja, "Sl. glasnik RS", 18/2020).

In the Republic of Serbia, the lessee and the lessor have a lot of freedom when it comes to the form of the contract and the price of the lease. However, this is not the case in some countries of the European Union. In many of them, the government has set limits on fees for renting agricultural land. The maximum, minimum or both limits of the rental price are determined. For example, in Belgium and the Netherlands a maximum price is indicated. This helps smaller farms to compete with larger ones, but in the Netherlands it has been shown to lead to informal agreements and the informal payment of higher rents (Ciaian et al., 2012a).

Contracting parties are obliged to comply with contractual rights and obligations, and if this is not the case, termination of the contract is possible (Riveros et al., 2022).

Research objective, methodology and sample

The aim of the paper is to point out the problems of tenants of agricultural land, from searching for land for lease, to getting information about the offer of land, to terminating the contract, but also to propose appropriate solutions to the problem.

Of the methods, quantitative and qualitative analysis was used, and the basic method of data collection was a survey questionnaire. For the purpose of analyzing the research results, the *Microsoft Excel* program was used.

The sample included 86 agricultural farms, and the survey questionnaires were sent in the period from May 22, 2023 to May 24, 2023. years. We received answers to the questionnaire from 24 farms (29.9%). The participation was rather modest, because the spring work was in full swing or the farmers did not want to devote time to other activities, which require deliberation.

Research area and profile of respondents

Zapadnobački District includes the territory of three municipalities (Apatin, Odžaci and Kula) and one city (Sombor), and is located in the northwestern part of AP Vojvodina. Most of the farms included in the sample are engaged in arable production. 24 respondents answered the questionnaire, of which only 1 farm was from the municipality of Kula. The municipality of Apatin did not have a single farm that responded to the questionnaire. 54.2% of the respondents were from the rural municipality of Odžaci and 45.8% of the respondents belonged to the city of Sombor.

Only two farms were in business for less than 5 years. Most farms have been operating for more than 15 years (70.8%), 12.5% had 11 to 15 years of experience, and the rest had 5 to 10 years of experience. Also, the sample included mainly larger farms, where more than a third of the respondents farmed property larger than 200 ha, while farms that farmed less than 50 ha were not included.

37.5% of respondents leased 41-60% of the total land they cultivate. In the case of 29.2% of farms, the share of leased land is 61-80%. 4.2% of farms rent almost all their land (in the range of 81-100%), and the same number of them rent very little land (in the range of 0-20%). 24.9% stated that the share of leased land is 21-40%.

In 2022, 38.5% of the land is owned, while 57.4% of the land is leased and only 4.1% of the land remains in use. The share of leased land on farms in Zapadnobacka District is relatively high, and leasing has an advantage over buying land.

Research results and discussions

The first question was: how to find agricultural land for rent? 79.2% of the respondents stated that the landowners themselves offered them the land. 62.5% of farmers go directly to ask the owner, and 45.8% find land for lease through the Agricultural Land Administration. It is less popular to look for land on the Internet - this is done by a quarter of respondents, and three respondents stated that they use the help of acquaintances and friends. Therefore, it can be said that in Zapadnobački district, the owners are concerned about their agricultural land and are quite inclined to offer it to farmers themselves for lease. Tarjuelo et al. (2020) point out that from the aspect of land management, it is better to cultivate it, than to leave it lying fallow.

Below (table 1) is shown how much land is leased from different lessors.

Table 1. Structure of lessors in Zapadnobački district (%)

Landlord	It is not rented at all	Less than half of the leased land	About half of the leased land	More than half of the leased land	The entire land is leased	Total
State	37.5	62.5	0	0	0	100
Physical persons	0	8.3	20.8	54.2	16.7	100
Farms bigger than yours	95.8	4.2	0	0	0	100
Farms smaller than yours	62.5	33.3	0	4.2	0	100
Other legal entities	45.8	41.7	12.5	0	0	100

The largest share of leased land is owned by natural persons, where 16.7% of respondents lease the entire land, and 54.2% of farms cultivate more than half of the land leased from natural persons. Active agricultural farms also have the possibility to lease land. It seems that this is not exactly the practice in the Zapadnobacka District, but still one farm (4.2%) leases less than half of the leased land from larger agricultural farms, while 33.3% of respondents also lease less than half of the leased land from smaller agricultural farms. Less land is leased from other legal entities and the state, whose share is less than half of the leased land.

When the land is found, a lease agreement should be concluded with the owner. We investigated which form of contract is most used by agricultural holdings and how often. 41.7% of respondents do not use the oral form of the contract at all, and the rest use it quite rarely. 70.8% of lease contracts are concluded in writing. The most expensive and comprehensive form of contract is the so-called notary form. 87.5% of respondents do not use it at all, and the rest use it quite rarely. Fortunately, no one had serious problems with the use of any of the mentioned forms of contract. Although there is freedom in the form of rental contracts in Serbia, it is still preferable that they be drawn up in writing.

When concluding a lease agreement, the lease price is discussed. In addition, the time period for which the land is leased is important. In the opinion of more than half of the respondents, it is important to negotiate the termination of the contract and the use of good agricultural practices. The survival of the contract is primarily important for the lessee, due to the organization of production. Since the duration of the lease agreement is one of the most important points of the contract, we investigated the time period for which farms in Zapadnobački District sign an agreement on the lease of agricultural land.

Table 2. Frequency of using different terms in the lease agreement (%)

Contract term	Not at all	Rarely	Sometimes	Often	Very often	Total
1 year	54.2	29.1	4.2	8.3	4.2	100
2 years	45.8	33.3	16.7	4.2	0	100
3 years	12.5	25.0	29.1	12.5	20.8	100
<3 years	8.3	4.2	12.5	25	50	100
Unlimited	41.7	16.6	25	4.2	12.5	100

Table 2 shows that more than half of the farms in the Zapadnobačka District do not sign a lease agreement for one or two years at all or do so rarely. Instead, a term of at least 3 years is agreed. Most often, the signing of a contract is for a fixed period of time, and for a period longer than three years.

Respondents stated whether they pay a higher rental price every year in the case of an indefinite-term contract. If the price of leased land on the market increases, then approximately three-quarters of households pay an increased lease price.

Next, we investigated the early termination of the lease. 8.3% of respondents had to terminate the contract, because the owner alienated the land without their knowledge. The lessor should inform the lessee about the alienation of the land. According to the contract, all rights and obligations agreed between them pass to the new owner. The new owner can cancel the contract under certain conditions, e.g. if he wants to start production. The lease agreement was also terminated earlier, because the tenant himself acquired the property. However, 45.8% of respondents stated that the lessor wants to terminate the contract early. The reason is mainly the death of the lessor, where the heirs decide to sell the land or start cultivating it themselves - this was stated by 58.3% of respondents. Half of the respondents said that the reason was the sale of the property or the desire to start using it themselves. A third of respondents stated that other farms offered a better price and that the lessor accepted a more favorable offer. Respondents state that there has been a termination of the lease agreement, because some lessors want to terminate the agreement without any reason. It seems that unjustified reasons are often found and that farmers give up relatively easily and prematurely terminate the contract at the request of the lessor.

We were interested in situations related to the termination of lease contracts on agricultural holdings in the Zapadnobačka District (table 3).

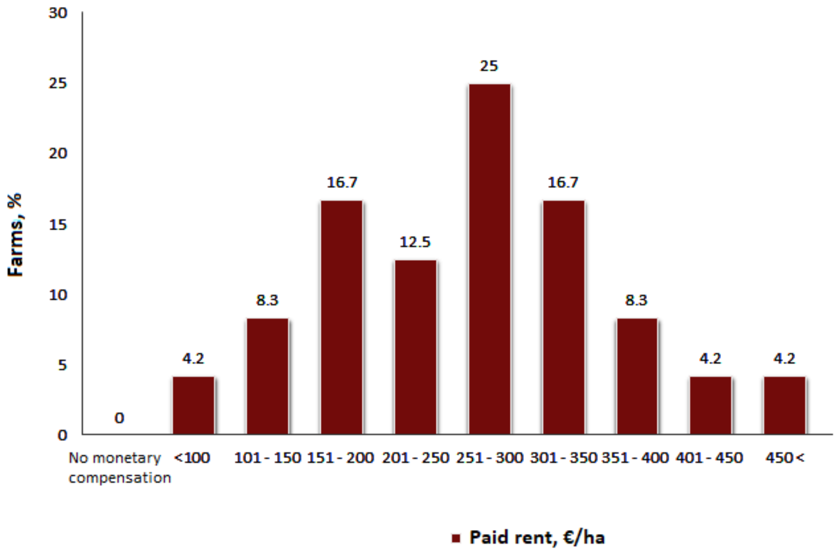
Table 3. Various situations to the detriment of tenants on agricultural farms in the Zapadnobačka District (%)

Frequency of occurrence	The lessor wants to increase the agreed fee before the contract expires	The landlord wants to receive the rent before the deadline specified in the contract	The lessor wants to terminate the lease before the term specified in the contract
Never	29.2	20.8	25
Rarely	33.3	45.8	62.5
Sometimes	25	29.2	8.3
Often	12.5	4.2	4.2
Very often	0	0	0
TOTAL	100	100	100

Table 3 shows that none of the mentioned situations happened very often. However, 12.5% of households often encounter landlords who want to increase the rent during the duration of the contract. 25% of the respondents stated that the landlords sometimes tried to increase the rent, and a third of the respondents pointed out that this is a rare case. The situation that the lessor wants to receive the rent before the term specified in the contract sometimes occurs with 29.2% of respondents, and less often with 45.8%. The case that the lessor wants to terminate the contract before the term specified in the contract occurs quite rarely in 62.5% of farms, sometimes in 8.3% of farms, and often only in one farm (4.2%).

The price is the most important element of the lease agreement. Therefore, the following graph shows the range of fees, which are paid per hectare for land lease in Zapadnobačka District.

Graph 1 shows the percentage of households that paid the appropriate rent in 2022. For 25% of respondents, the fee for renting 1 ha is 250 - 300 euros. Furthermore, 16.7% of households paid rent between 150 - 200 euros. Also, 16.7% of households paid rent in the amount of 301 - 350 euros. There were no farms that received land without monetary compensation. 1 farm paid a rental price above 450 euros/ha.



Graph 1. Lease fee per hectare of agricultural land on the farms of Zapadnobački district (2022)

Therefore, the range of rent for land, which is paid for in Zapadnobačka District, ranges from 100 - 450 euros. The average fee for the lease of agricultural land in Zapadnobačka District is around 300 euros per hectare in 2022, with a growing trend. When it comes to state land, the initial price for most plots in the area of the city of Sombor is also around € 300/ha (Uprava za poljoprivredno zemljište, 15.06.2023). Agricultural land lease prices in Zapadnobačka District can be considered somewhat higher than the average in the Republic of Serbia.

How much someone will pay to rent agricultural land depends on the supply, but also on other factors (Davies et al., 2007). We investigated the factors influencing the price of land lease (table 4).

Table 4. Factors that determine the price of land lease on farms in Zapadnobačka District (%)

A factor affecting the rental price	It doesn't matter at all	Does not matter	Moderately important	It's important	Very important	Total
Market price	4.2	12.5	25	20.8	37.5	100
Soil fertility	0	8.3	16.7	41.7	33.3	100
Land distance	0	4.2	12.5	50	33.3	100
Land size	8.3	4.2	16.7	33.3	37.5	100
Competition	4.2	4.2	8.3	29.2	54.1	100

More than half of the farms believe that the strength of competition greatly affects the price of agricultural land lease, and more than one-third of them point out that the market value and the size of the land for lease play a role. Furthermore, the fertility of the soil is always taken into account, as well as the distance of the land from the farm. No one has indicated that these two factors are not important at all. The most conflicting opinion is about the "market price", whether it is very important or not.

Solutions to problems related to land lease

Agricultural farms faced several problems related to land lease, namely:

- find land for rent,
- rental prices have become very high,
- rent increase,
- tenants want to receive rent for several years in advance,
- premature termination of the lease agreement.

Rent does not always have to be in money. The rent could be paid in another way, e.g. products, agricultural services, etc. The tenant can respond to the request for a rent increase, if it is economically justified. If the rent is specified in a multi-year contract, it cannot be increased. However, for contracts with a longer duration, it can be beneficial for both parties to agree on the rent as a variable amount. If the tenant is willing to pay the rent for several years in advance, this should definitely be included in the contract. For smaller farms, it would be beneficial for the state to determine the maximum rental price by land class, but this would limit free competition.

The results show that farms from Zapadnobačka District had problems with lessors, who want to terminate the contract early. It would be very important for the tenant to know the reasons for early termination of the contract. In order for the lessor to terminate the contract early, he must state a valid reason and give a notice period, if it is a contract for an indefinite period. The contract can only be terminated in such a way that it ends at a time when there is no production on the land. Justifiable reasons could be taken into account, e.g. if the tenant fails to pay the rent or is bankrupt. Also, if the tenant uses the agricultural land in such a way that its value drops significantly. Also, if the lessee believes that the reason given by the lessor is not valid, he can refuse the termination and demand the continuation of the contract. If the reason for terminating the contract is that someone offered a higher rent or nothing was said, then this cannot be considered a valid reason and the tenant can continue to use the land until the agreed term. In order to protect your rights, you should draw up a written contract, and in case of a dispute, go to court.

In some countries there are very many regulations related to the rental agreement. Of course, it would be much easier for both contracting parties in this case. However, the value of a lease agreement is that it is relatively flexible in terms of price, validity and form, and if either party needs to withdraw from it, they can do so.

Conclusion

The share of leased land on farms in AP Vojvodina has been increasing in recent years. The reason for this is the increase in demand for agricultural products, which in turn led to the need to expand production capacities.

It has been shown that the main advantages of renting agricultural land are that there is capital left for other investments and it is a way to start production without owning the land. Until now, the lease has been relatively flexible in terms of price, validity and form of contract. There are different ways to lease agricultural land, such as taking it through public bidding, directly from the owner and through a real estate agent. The rent or land use fee is high. When you make the decision to rent, you have to think about what form of contract to opt for and for what period of time.

The results revealed that there are problems with the lease of agricultural land. Although rental prices in Zapadnobačka District are high, the demand for land rental is at a high level. In addition, non-transparent bidding, early cancellation of contracts, lack of land for lease, are the problems faced by tenants.

Basically, the early termination of the contract is due to the request to transfer the land or the owner wants to start his own production. Competition is strong and there is not enough land to lease. Rents are also very high, landlords increase them or want to get them in advance. Although many safe, written contract forms are used, tenants could take more measures to maintain the contract, and it is certainly recommended to do business with landowners who have a good reputation.

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ANIMAL INSURANCE IN SERBIA

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Abstract

The sector of the economy that is of vital importance for the overall social and economic development of the country in Serbia is agriculture. The position of the agricultural sector in Serbia is specific, because in addition to its economic importance, it has a special social and ecological importance, and agriculture contributes to the national wealth by significant participation in the creation of GDP. There are no restrictions when it comes to insurance in agriculture, i.e. not only crops and fruits are insured, but also livestock, domestic animals, and not often greenhouses, forestry and aquaculture can also be insured. In EU countries, agricultural insurance (crop, fruit and animal insurance) is regulated by law, while in our country it is still up to the producers to decide whether they will bear the risk or insure agricultural goods and livestock. Animal insurance involves a large number of risks and is classified as risk insurance. It belongs to the group of short-term insurances, i.e. insurances up to one year or even shorter. The subject of insurance is the animal itself, not only individual parts of the animal's body or products that can be obtained from it.

Key words: Agriculture, agricultural insurance, animal insurance, risk.

Introduction

Animal insurance has been an increasingly common topic on farms and farms in recent years. Despite the careful and diligent breeding of domestic animals, farmers face a large number of unwanted events. Animals are prone to injuries, diseases, and it often happens that they die. Also, in recent years, Serbia has been struggling with floods (impact of climate change), so it happens that a large number of animals are killed by water torrents. For farmers, this represents a big loss, that is, it causes big costs. Such circumstances cannot be prevented, but domestic animals can be insured, and thus farmers can be insured against losses. The subject of insurance can be all domestic animals, cattle, sheep, goats, pigs, ungulates, and pets, i.e. dogs and cats, are increasingly insured. Only healthy animals, i.e. animals fit for a specific purpose, which are in good physical condition, animals that live in normal conditions and eat healthily, but above all animals that have been identified, are subject to insurance. Livestock insurance belongs to agricultural insurance. This type of insurance is carried out by insurance companies dealing with non-life insurance. Livestock insurance is underdeveloped in Serbia. In general, a very small number of agricultural farms decide to conclude a livestock insurance contract (Katrinka, Brkanić, 1996).

Livestock production is exposed to different dangers compared to crop production. The insurance contract is concluded on the basis of a verbal or written offer, and it is concluded when the contracting parties sign the insurance policy. Animal insurance contracts are signed for a shorter period of time up to one year or for a period of time longer than one year and are long-term animal insurance contracts. It often happens that contracts are signed for a shorter period of time, and then they are extended from year to year.

The insurance contract provides adequate coverage for the time that the insured animals are in the place specified in the policy as the place of insurance, i.e. in the facilities, the area of their regular residence and feeding. Animals are also insured during their stay on the land owned by the insured, at regular meat and nearby livestock fairs, as well as during driving and transportation to and from that place, and the furthest 20 km from the place specified in the policy as the place of insurance.

The subject of consideration in this paper is the insurance of domestic animals. This area of insurance in our country is not yet sufficiently developed. More attention is paid to crop insurance than to animal insurance. In recent years, dog and cat owners are increasingly choosing to insure their pets. It should be borne in mind that every large farm should insure its herds and thus insure itself against possible risks or losses. The insured has the right to receive compensation, if the insured event occurs. When the insured event occurs, the owner is obliged to take appropriate actions, both for the purpose of treatment, and for the eventual maximum use of the salvaged remains in case of death/forced slaughter.

The main goal of this work is to show what the situation is with regard to the insurance of domestic animals. The main task of this work is to find an answer to the question why there is no interest of owners of domestic animals to insure them? Also, it should be determined why this type of insurance is still combined with insurance in agriculture. Then it is necessary to investigate what role the state can play in order to contribute to the interest of owners to insure their domestic animals.

The concept of animal insurance

Animal insurance refers to the financial protection of animal owners against various risks that occur when raising animals. The subject of this insurance is all domestic animals raised on farms (cattle, sheep, goats, pigs, poultry, horses), but also pets such as dogs, cats, parrots. Insurance covers the risks of death or forced slaughter of animals as a result of: an accident (basically narrower coverage), an accident or illness (basically broader coverage) (Manić, 2012).

How much the insurance premium will be depends on the type of animal that is the subject of insurance, then the number of animals that will be insured, the conditions and methods of raising the animal, the risks for which the animals are insured, as well as their estimated value and the amount of coverage that is defined by the contract. Payment of the insurance premium can be made on a monthly basis, then quarterly, semi-annually or in advance. If the agreement also includes participation in damages when it is a normal death of the animal, it is possible for the owner to obtain a discount on the insurance premium of up to 50%. Then, depending on the number of insured heads and the method of premium payment, it is possible to obtain a discount of up to 30% on the basic insurance premium (Stojković, 2008).

With animal insurance, it is possible to obtain a number of additional benefits. For example, for animal owners who sign an insurance contract and pay the premium in advance above a certain amount, an additional benefit is provided in the form of free insurance against the consequences of an accident. This insurance is usually given for a period of one year, and from the consequences of an accident, it insures the entire farm, i.e. all its members.

The state also encourages animal owners to insure them by subsidizing this type of insurance. To agricultural holdings that are registered, the state returns a certain part of the insurance premium suffered, where the provisions are more closely defined by the competent ministry.

Risks in animal insurance

Insurance of animals involves a large number of risks and falls under the category of risk insurance. It can appear in several different forms: basic insurance, a large number of supplementary and special insurances, sample insurances for certain types of animals that are insured for the first time, that is, for risks for which coverage is given to the insured for the first time. It belongs to the group of short-term insurances, i.e. insurances up to one year or even shorter. The subject of insurance is the animal itself, not only individual parts of the animal's body or products that can be obtained from it. Insurance coverage is provided only for animals up to a certain age, which are above all healthy, in good physical condition and which are raised in good and quality conditions. (Žarković, 2016)

The question is often asked, why is animal insurance still underdeveloped in Serbia? The reason for this is primarily the low paying power of agricultural producers, then lack of information about the importance of animal insurance, but also the decline in livestock production in recent years.

Domestic animal insurance

Livestock insurance belongs to agricultural insurance. This type of insurance is carried out by insurance companies dealing with non-life insurance. Livestock insurance is underdeveloped in Serbia. In general, a very small number of agricultural farms (5-10% of the total number) decide to conclude a livestock insurance contract.

When it comes to livestock insurance in Serbia, the general conditions of livestock insurance brought by one of the more successful insurance companies are analyzed, and attention is paid to the way agricultural insurance premiums are subsidized, including livestock insurance, which is supported by the Government of Serbia. On the other hand, significant attention is paid to livestock insurance in Mongolia, India, Mexico and Ireland, which have defined livestock insurance programs that have contributed to a greater number of concluded contracts in this area. In Mongolia, the mentioned program is implemented through the insurance of the unified risk, in India this insurance is implemented at the level of the local community (village), in Mexico through self-insurance funds and the so-called "stop-loss" reinsurance, and in Ireland various programs are defined for the control of animal diseases and their eradication. (Marković, Jovanović, 2010)

It should be said that livestock insurance does not have the place it should have within agricultural insurance. In the world as well, livestock insurance represents a relatively small segment of total agricultural insurance, even in highly developed countries.

Subject of insurance

In the case of plant production, the subject of insurance is usually the fruit, that is, the product itself, and in rarer situations also the tree. In the case of animal insurance, the entire animal is insured, and not the products they give us, such as milk, eggs, meat, wool, skin.

In animal insurance, the animal itself is the subject of insurance, not individual body parts or products that animals give us (Cogoljević et al., 2018). The subject of insurance is all types of domestic animals (ungulates, cattle, sheep, goats, pigs, bees, dogs, trout, pheasants, rabbits, turkeys, turkeys, peacocks and poultry); wild and exotic animals in and out of zoos.

There are no limits when it comes to animal insurance. All domestic animals that are raised by the person themselves, that is, that are owned by the person as an individual or a farm, farm, etc., can be insured. Only healthy animals can be insured, with a veterinarian's confirmation, i.e. a control examination performed before the insurance is signed by expert veterinarians.

Sick animals or animals prone to diseases, as well as emaciated and exhausted animals cannot be insured. Also, the subject of insurance cannot be domestic animals that are not in good physical condition or the conditions in which they live are bad. (Piljan et al., 2019)

Types of insurance

Animal insurance is a special branch of agricultural insurance. Considering the many types of animals and the risks involved in raising them, this insurance comes in different forms: (Marković, Jovanović, 2010)

- Basic animal insurance,
- Supplementary and special insurance and
- Sample insurances for those types of animals and risks that are being insured for the first time.

Additional types of animal insurance

Supplementary animal insurances include animal insurances for which there is very little interest, i.e. animals that are not covered by the basic insurance, or specific situations in which animals can be found, which may be risky for their lives (animals dying during childbirth, etc.). (http://www.generali.rs., 2023)

The state of animal insurance in Serbia

Globally today, crop insurance accounts for 90 percent of total agricultural insurance premiums. Due to the emergence of new diseases that are current in animals today, the need for livestock insurance is also increasing. In order to achieve complete economic protection, a "tighter connection between farmers, insurance companies and the state is necessary in order to create an integrated system of risk management in animal husbandry". (Katrinka, Brkanić, 1996)

It is considered that the costs of agricultural insurance, i.e. crops, fruits and animals, are almost negligible compared to the benefits of the farmers, i.e. the insured. Although the theoretical positions are different, in practice animal insurance as part of agricultural insurance is still underdeveloped in a large number of countries. The same situation exists in Serbia, where animal insurance is underdeveloped both in terms of scope and type of protection.

The possibilities for the development of insurance in Serbia are much greater than the current level of its development. The development of animal insurance in Serbia today is at an extremely low level, regardless of the support of the state and the introduction of subsidies on the insurance premium. This further indicates that the subsidy provided by the state is not sufficient to achieve greater expansion of animal insurance in our market. (Piljan et al., 2015)

Insurance is primarily needed for the development of agriculture in general, but also for the rural development of the country, but above all to ensure food security. This is primarily important in domestic conditions, primarily due to the fact that rural areas make up as much as 85% of the total area of our country, that the percentage of agriculture in the gross domestic product is large, but also in exports and the total employment of the population.

The results of the last agricultural census conducted in 2012 show that there are 631,522 agricultural farms in Serbia, and of that number, 99.5% are family agricultural farms that are also responsible for food security. Looking objectively, the need for animal insurance exists and is very pronounced, given the fact that crop and livestock production in Serbia is exposed to numerous risks, which are increasing year by year, especially when it comes to climate change.

The subjective need for agricultural insurance in domestic conditions is not sufficiently developed due to low paying power, that is, the economic underdevelopment of agricultural subjects, as well as low awareness of the importance of insurance. The underdevelopment of agricultural insurance at the micro level also conditions its underdevelopment at the macro level, as a consequence of the underdevelopment of agriculture, as an economic activity of national importance.

Analyzes of the four largest insurance companies in Serbia, which together cover the entire agricultural insurance market in the Republic of Serbia, in addition to the basic conditions, there are numerous special conditions for insurance of crops and fruits, as well as for insurance of animals.

As for the special conditions for crop and fruit insurance, you should definitely refer to the insurance of seed corn against the loss of seed quality due to autumn frost, the insurance of table grapes against the loss of quantity and quality, the insurance of fruit trees and vines - young plants until they go into harvest. as well as plantings in the field, and there is also a trial of oilseed rape from winter freezing.

Based on this analysis of agricultural insurance on our market, we come to the conclusion that the most important risks of crop and livestock production are covered by the conditions of agricultural insurance of insurance companies operating in the territory of the Republic of Serbia. What can be said to be lacking in these insurances is insurance against drought and loss of income due to drought, which is offered by only one insurance company in the territory of the Republic of Serbia.

The State of Serbia, in cooperation with the Ministry of Agriculture, is regressing the agricultural insurance premium starting in 2006. The number of agricultural farms, which in the period from 2006-2015 exercised the right to recourse to agricultural insurance premiums, was very variable. In the last observed year, 2015, the right to regress the insurance premium was realized by 19,799 agricultural farms, namely 18,268 farms for plant production insurance, and only 1,531 farms for animal insurance. (Piljan, Cogoljević, 2015)

The clear conclusion is that in 2015, 19,799 agricultural farms were insured, which represents only 3.13 percent of the total number of agricultural farms in the Republic of Serbia. The total number of agricultural holdings in the Republic of Serbia was determined in the last agricultural census in 2012 and amounts to 631,552 holdings.

In order to develop insurance in agriculture on the territory of our country, it is necessary to introduce partially mandatory insurance in agriculture. That is why it is necessary to legally define this type of insurance as partially mandatory, as well as to adopt a strategy for the development of agricultural insurance in the Republic of Serbia. The proposed model of partially mandatory agricultural insurance is based on a public-private partnership, and its application would enable the development of agricultural insurance, but also provide the necessary financial resources for current and investment financing of this significant economic activity.

Partially compulsory agricultural insurance means compulsory agricultural insurance for all agricultural entities, users of a state resource, from those risks that are most common in a certain area.

According to the proposed model, agricultural insurance should be mandatory:

- For beneficiaries of incentive funds for the development of agriculture that are paid from the republican, provincial or local self-government budgets;
- For users of loans that are approved with subsidized interest with funds from the state budget;
- For users of loans that are approved by state financial institutions and that are placed with a low (subsidized) interest rate;
- For tenants of state agricultural land.

It should also be said that, according to the current policy of commercial banks, there is now only mandatory insurance for animals, and that if the credit user intends to use those financial means to realize their purchase. In accordance with the proposed model of partially mandatory agricultural insurance, agricultural entities (legal and natural persons) should, when applying for state subsidies, for loans with subsidized interest, as well as for the lease of state agricultural land, attach an insurance policy as part of the mandatory tender documents .

Agricultural insurance should also take its place in Serbia in the modern market economy. Modern, market-oriented agriculture cannot even be imagined without well-organized and developed insurance. The perspective of the development of agricultural insurance in domestic conditions should imply a much more active role of the state than until now.

The state's role could also be reflected in the introduction of partially mandatory agricultural insurance, as well as in the provision of funds from the agricultural budget for higher insurance premium subsidies. At the same time, insurance companies should play a key role in the domestic market of agricultural insurance by developing supply and demand, as well as in informing and educating agricultural subjects about the importance of economic protection of their production.

Conclusion

In Serbia, agricultural insurance is one of the underdeveloped insurances. The perspective of its development in domestic conditions should include a much more active role of the state than until now.

The main goal of animal insurance is the economic protection of animal owners who keep healthy animals, while ensuring that all conditions for quality animal breeding and exploitation of their products are provided. Although the animals are insured against certain risks, this does not release the insured from the obligation to approach production with the attention of a good householder, as prescribed by the Law on Obligations.

Due to the existence of numerous risks and types of animals, animal insurance occurs in different forms: basic insurance, a large number of supplementary and special insurances, sample insurances for certain types of animals that are insured for the first time, i.e. for risks for which coverage is given to the insured for the first time. Animal insurance is short-term insurance that lasts a year or less and is usually tied to one production cycle. The subject of insurance is the animal as a whole, not its product or part. Insurance coverage can only be provided for animals of a certain age, which are healthy, in good condition and raised in acceptable conditions.

The importance of agricultural insurance is reflected in the provision of economic protection to farmers from various harmful effects that occur due to the risk covered by the insurance. Agricultural insurance is an important factor in the protection and improvement of agricultural production.

One of the good solutions that could improve the market is a model in which, as a condition for obtaining subsidies in agriculture from the state, the obligation to pre-contract appropriate insurance coverage would be introduced. This would have a multiple effect, on the one hand, the income of agricultural producers would be predictable, while, on the other hand, the state would protect the invested funds in the form of subsidies in agriculture and, in addition, secure the state budget from further unplanned expenditures. Also, one should not ignore the positive effect on the insurance industry in general, but also the return effects in terms of the development of preventive measures and education about the present risks of agricultural production and measures to overcome them.

The conclusion is that only through mutual engagement and synchronized action of the state sector and the insurance industry can they achieve more visible positive developments in this area. Insurers in their domain should offer the market an adequate product in terms of comprehensiveness (covering more risks), clear and as simple as possible definition of insurance conditions and tariffs and as easy as possible accessibility to the insured, which will be of unequivocal benefit to everyone, including agricultural producers, the state sector and industry insurance.

Following the example of developed world markets, the second part of the work would have to be taken over by the state through appropriate subsidy systems, public-private partnership models, and the adoption of appropriate legal and by-law regulations in this area. In the time to come, the establishment of quality cooperation between the insurance industry and the public sector to improve the current situation in the Republic of Serbia will be key to utilizing the development opportunities that certainly exist in this extremely important area.

The state's role could also be reflected in the introduction of partially mandatory agricultural insurance, as well as in the provision of funds from the agricultural budget for higher insurance premium subsidies. At the same time, insurance companies should play a key role in the domestic market of agricultural insurance by developing supply and demand, as well as in informing and educating agricultural subjects about the importance of economic protection of their production.

The proposed model of partially mandatory agricultural insurance is based on a public-private partnership, and its application would enable the development of agricultural insurance, but also provide the necessary financial resources for current and investment financing of this significant economic activity.

Animal insurance provides financial protection against various risks characteristic of livestock production, that it is necessary to harmonize domestic regulations on domestic animal insurance with European Union regulations, that the state must provide assistance when it comes to animal insurance, through various subsidies and tax reductions for farmers, that farmers they must take into account that insuring domestic animals can bring them great benefits and reduce the damage caused by any form of animal loss, that the entry of foreign insurers raises the level of quality of insurance services and creates conditions for further market liberalization, that changes in insurance can have a positive impact on the further development of the insurance market in Serbia and contribute to its accelerated approach to the European Union.

Based on everything presented in the paper, we can say that the main hypothesis, as well as all special hypotheses, has been confirmed.

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DEVELOPMENT OF THE ECONOMIC POTENTIAL OF THE GREEN ECONOMY IN RURAL AREAS OF THE REPUBLIC OF SERBIA

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Abstract

The aim of the paper is to examine the theoretical and methodological aspects of the economic potential of the development of the green economy in rural areas. The research methodology includes the analysis of reports, studies and publications on various aspects of the green economy and green development. Based on theoretical sources and a holistic approach, the main characteristics of the model of rural development based on the principles of green economy, which can be applied in the Republic of Serbia, have been identified. The realization of the economic potential of the green economy in the model of rural development implies decarbonization, circular economy, reduction of pollution, sustainable agriculture and biodiversity. Accordingly, in reaching the goal, the conclusion of the study suggests the necessity of including natural, technical, infrastructural, demographic, financial and investment components as well as the readiness of local communities.

Key words: Green economy, green growth, rural development, organic agriculture.

Introduction

The development of rural areas in conditions of increasingly intensive urbanization around the world, and therefore also in the Republic of Serbia, faces numerous internal and external challenges. Environmental, institutional, economic-financial, social, regional, global challenges require significant attention and the most effective socio-economic mechanisms. Therefore, a universal model for sustainable rural development does not exist, but depends on local development potentials and the socio-economic environment.

Accordingly, in their studies the authors Bogdanov, (2015) and Hodge et al., (2017) direct attention to sustainable rural development. The joint conclusion of the study suggests taking actions at the level of theoretical developments and practical implementation of policies both at the regional and global level. Accordingly, looking at the economic, ecological, social, energy, cultural-historical, infrastructural, spatial and other components of rural development is a very complex task. In order to find answers to the most important issues of sustainable rural development in many countries, international organizations have been established that deal with this issue.

Numerous dilemmas about how to manage the sustainable development of rural areas and the diversity of interpretations of the green economy concept determine the lack of theoretical and methodological developments that adequately explain the formation of green "growth points" within the boundaries of rural areas (Tambovceva and Tereshina, 2018). In the context of numerous problems of the rural areas themselves, the starting hypothesis is that the basis for the formation of a modern policy of sustainable development of rural areas is the identification and development of the economic potential of the green economy. Additional support for this research is represented by official statistical data related to the researched topic in the paper.

Sustainable rural development - theoretical insight

Since rural areas are not closed, rural development mechanisms have a dynamic nature. These mechanisms change not only in accordance with the strategies of different social and institutional structures and political forces, but also due to changes in global trends of socio-economic development.

Traditional approaches to the development of rural areas viewed them mainly as a set of resources, that is, a "reservoir" for the development of production processes in agriculture. Accordingly, a large number of authors in their studies have analyzed new approaches in the development of agriculture and rural areas (Asseng and Asche, 2019; Bramley and Ouzman, 2019; Borgen and Aarset, 2016). In contrast to this approach, in the conditions of today's development, a new approach to rural development was formed (Guinjoan et.al, 2016). The focus of the new approach is more on qualitative rather than quantitative parameters of the development of rural areas. More precisely, the approach takes into account the specific local resources of local communities in the field of development, with an emphasis on ecological aspects. The basis for the sustainable development of rural areas is determined by "green" activities and the circular economy paradigm (D'Amato et.al., 2017). The necessity of introducing the principles of green economy into the economic practice of rural areas is primarily determined by the significant dependence of the rural economy on industry, as well as the growing negative impact of agricultural production on the environment.

Unlike the traditional ecological approach, which to a large extent implies certain limitations of economic development in rural areas, "green growth" serves as a catalyst for investments and innovations. In addition, green growth creates new economic opportunities, serves as a basis for structural changes in favor of technologically advanced industry and activities (Melece, 2016). The existence of certain "gaps" between challenges and threats that constantly arise in the socio-economic space of rural areas raises the question of developing new conceptual schemes and analytical tools for studying the development of rural areas in the context of the green economy.

Table 1. Model and main characteristics of green development in rural areas

Objectives of rural development management	• Optimal use of local resources • Diversification of activities through the development of green industry (sustainable resource management, circular economy, waste recycling, sustainable tourism, etc.) • New forms of cost reduction (saving resources)
The main drivers of development	• State support at the national and regional level • Political will at the local level • Demand for environmental goods and services in rural areas • Socio-ecological responsibility of business • Deterioration of the environment
Dominant sectors of the economy	• Central place - intensive agriculture of the traditional type with the introduction of ecologically acceptable technologies • Central place - Organic agriculture • Diversification of the local economy into basic green branches and industry • circular economy,
The role of local self-government	• Central place - network local structure • Rural development understood as a multi-factor process • Central place - partnership concept
Future institutional structures	• Active forms of intersectoral interaction • Multi-level management

Source: Author

Activities in the field of rural development based on "green" growth in the world

When talking about the concept of a green economy, another myth burdens the aspirations to create. Namely, on the one hand, it is often heard that this is a luxury that only the richest countries can afford. On the other hand, this is just the way rich countries want to limit the development of the underdeveloped and leave them in a state of poverty. Contrary to this perception, today one can find a number of examples in different sectors in developing countries, which prove that the transition to a green economy is something that brings great benefit to these countries and can be replicated to a large extent in all parts of the world. The concept of green economy proposes new possibilities for future growth in the world through the reduction of pressures on the environment. (UNEP 2011). Using natural resources in such a way that they remain available for future generations is the best way to harmonize environmental protection and economic values (Ilić and Pavićević, 2018).

In response to these challenges, Rural Development Programs (RDP) help rural areas to respond to a wide range of economic, environmental and social challenges. The main activities supported by such programs include: green technologies in waste management, sustainable water management, eco-tourism, sustainable buildings, services and infrastructure investments in natural capital. The fastest growing sector of the green economy in rural areas is organic agriculture (Table 2).

Table 2. Main indicators of the development of organic agriculture in the world

Region	Organic agricultural land [ha]	Share of total agricultural land [%]	Regions' shares of the global organic agricultural land [%]	Numbers of producers by region 2020 [no.]	Numbers of producers by region 2021 [no.]	1 year growth [%]
Africa	2.663.983	0,2%	3,5%	968.233	1.123.255	16,0%
Asia	6.504.211	0,4%	8,5%	1.811.209	1.782.134	-1,6%
Europe	17.844.853	3,6%	23,4%	417.987	442.274	5,8%
Latin America	9.870.887	1,4%	12,9%	262.115	280.436	7,0%
Northern America	3.542.140	0,8%	4,6%	22.448	23.392	4,2%
Oceania	35.985.809	9,7%	41,1%	15.930	18.479	16,0%
World*	76.403.777	1.6%	100%	3.496.898	366.9201	4,9%

Source: Author calculations based on the FiBL survey, 2023

Organic Agriculture: A Case Study of the Republic of Serbia

Organic crop production in the Republic of Serbia in 2019 took place on a total area of 21,264 ha, which is 10.44% more than the total area in 2018. Of this, the arable area was 15,915 ha, while meadows and pastures had an area of 5,350 ha. Observing the period of the previous 8 years, a growing trend of the total areas under organic production can be observed (Table 3). In that period, the total area increased by 263%, while the arable area increased by almost 472%. In the last two years (2018 and 2019), a significant increase in the area under meadows and pastures can be observed due to the development of livestock production (Simić, 2021).

Table 3. Areas under organic production (2012-2019)

Year	2012	2013	2014	2015	2016	2017	2018	2019
Areas under organic production (ha)	6.340	8.228	9.548	15.298	14.358	13.423	19.254	21.265
Total arable area (ha)	5.364	5.355	7.999	13.398	12.929	11.875	13.723	15.915
Meadows and pastures (ha)	976	2.873	1.549	1.900	1.429	1.548	5.531	5.350

Source: Ministry of Agriculture, Forestry and Water Management, 2021

Looking at the categories of production in relation to the total arable area, arable production was the most represented and took place on 9072 ha, which is 57%.

Then comes fruit production with 5,324 ha, which accounts for 33.5%, while vegetable production represented 1.15%, and took place on only 184 ha (Table 4).

Table 4. Structure of organic plant production (2012 – 2019)

Type of production (in ha)	2012	2013	2014	2015	2016	2017	2018	2019
Cereals	2.522	2.273	2.829	4.252	4.607	3.662	3.614	4.788
Industrial plants	541	673	1.228	2.674	2.918	2.291	1.962	2.226
Fodder crops	663	107	1.204	1.440	1.349	1.211	1.336	1.797
Vegetables	114	1.484	154	171	184	230	199	184
Fruits and vines	1.416	595	2.208	2.895	3.531	4.056	5.883	5.324
Medicinal and aromatic herbs	28	133	61	71	113	115	193	261
The rest	80	90	316	1,895	227	312	536	1.332
Total arable area	5.364	5.355	7.999	13.398	12.929	11.874	13.723	15.915
Meadows and pastures	976	2.873	1.549	1.900	1.429	1.548	5.531	5.349

Source: Ministry of Agriculture, Forestry and Water Management 2021

Areas that make up the category of other include areas without crops, isolation belts, planting material, parlog and other various crops, were represented by 8.35% (Simić, 2021).

Through the analysis of the statistical indicators of the development of organic production in the Republic of Serbia, a strong development trend characterized by:

- growth of areas under organic production;
- development of livestock production;
- growth in the number of organic producers;
- development of the processing sector;
- market development and
- export growth.

The world market of organic products is constantly growing. The demand for organic products is growing in many countries, new markets for these products have opened up in recent years. The Republic of Serbia has exceptional ecological and climatic conditions that, in addition to the traditional production of berries and other fruits, produce vegetables, cereals and oilseeds from organic production, which are in high demand on the international market. The use of the Instrument of Pre-Accession Assistance for Rural Development (IPARD), which has been implemented since 2018, is a great chance for the organic production sector and therefore rural development in the Republic of Serbia (Ministry of Agriculture, Forestry and Water Management 2021).

Possible directions of development of the economic potential of green growth in rural areas

The differentiation of rural areas makes it necessary to identify specific directions for realizing the potential of the "green" economy. In most countries, the criteria for dividing urban and rural areas are population, population density and the nature of employment. As defined by the Organization for Economic Co-operation and Development (OECD), rural areas cover the population, land and other resources of open landscape and small settlements outside the immediate economic zone of influence of large urban centers. The OECD typology includes the following types of rural areas (Tambovceva and Tereshina, 2018).

1. Economically integrated territories - located in the immediate vicinity of business centers. These territories are characterized by a relatively high population density, a significant supply of jobs as well as a well-developed infrastructure. The preservation of the ecological balance and the protection of the natural environment are very important in these areas. However, agricultural production in economically integrated territories is limited by high land prices. Green development in these territories can be achieved by undertaking activities such as: waste processing, development of technologies for saving resources and energy in residential and communal services, development of environmentally friendly modes of transport, development of technologies and production of RES, introduction of technologies for saving resources based on intensive forms of production and processing of agricultural products.
2. Transitional territories of medium development - they are located in places connected to traffic main roads and are highly dependent on agriculture and related industries. There are two factors for their development: growth rates in the structure of production and agriculture and the development of industries that create the possibility of employment for the population of these territories. Depending on the resource potential, organic agriculture, agrarian tourism, development of renewable energy sources and afforestation can encourage the green development of such rural areas.
3. Far from the centers of economic activity - the possibilities for economic development in these regions are very limited. These regions are characterized by low population density, low incomes and high dependence on agriculture, as well as an unfavorable demographic structure. Directions for realizing the potential of green growth in such territories include providing local communities with energy resources based on local renewable energy sources, developing organic agriculture, ecological tourism, preserving landscapes, forest and meadow land, and using the working potential of local communities.

Bearing in mind the above, the approach to assessing the resources of local communities in rural areas determines the priority directions of private financing and state support in achieving the goals of green economy and green growth.

Conclusion

In the tripartite structure of sustainable development (society, economy and environment), green growth policy regulates where economic interests can be used as a means of promoting optimal environmental management and social equality. In this context, they propose the best options for development. For the successful implementation of the economic potential of the green economy in rural areas, the economy must change so that human well-being is realized without the accompanying destruction of the ecosystems on which that well-being largely depends. Therefore, the differentiation of rural areas determines the need for directions for the implementation of green development activities of all types of rural territories. Finally, the approach to the development of rural areas in the Republic of Serbia requires consideration of the resource potential and specific conditions of local communities. In addition, the adoption of adequate plans and strategies necessary for the implementation of the economic potential of the green economy is extremely important.

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FOOD SYSTEM – CONCEPT AND ANALYSIS OF INDIVIDUAL COMPONENTS

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Abstract

The aim of the paper is to present and analyze the food system and especially the segment related to the production of the most important agricultural products, as well as their consumption, based on which it will be seen whether there are pressures that threaten the ability to meet the nutritional needs of the global population. The analysis covers the period from 2012 to 2021 and follows global food production trends the most important groups of food products: cereals, meat, milk and eggs. Primarily, data from the Food and Agriculture Organization were used, where relative indicators such as average growth rates and base indices were calculated. Average production of cereals in the world in the period 2012-2021. year, amounts to about 3 billion tons, while meat production is constantly increasing and is around 330 million tons.

Key words: Food system, global trends, agricultural products, population needs.

Introduction

The production, distribution, management of food and food waste can have a negative impact on the planet. The way food is produced and consumed is increasingly threatening the planet. Food systems are intrinsically linked to health, environment, culture, politics and economics.

The degree of food insecurity shows that 17.2% of the world's population or 1.3 billion people experienced moderate levels of food insecurity. Total moderate and serious/severe food insecurity refers to about 26.4% of the world's population, which amounts to a total of about 2 billion inhabitants. People experiencing moderate food insecurity face uncertainty about their ability to obtain food and they are sometimes forced to reduce the quality and even quantity of food they consume at times during the year due to lack of money or other resources. On the other hand, people who face severe food insecurity, run out of food, have experienced hunger, even go without meals for several days, their health may be at serious risk (FAO, IFAD, UNICEF, WFP and WHO, 2019). Extreme climate events, conflicts, wars and economic slowdowns as well as crises continue to cause hunger in many parts of the world. The number of people who are undernourished actually increased from 785 million in 2015 to 822 million in 2018 (von Grebmer et al., 2019).

More recent FAO reports from 2021 represent the first global assessment of food security and malnutrition and provide indications of what hunger might look like by 2030. The Sustainable Development Goal of ending hunger ("zero hunger") is particularly emphasized, where it is indicated that around 9 % of people in the world face hunger, and if the growth trend continues by the end of 2030, the population would exceed 840 million (FAO, IFAD, UNICEF, WPF and WHO, 2021).

The food system is part of the entire national or international economic system and includes a part of social, technological and economic activities whose task is to meet the nutritional needs of the population, which directly or indirectly affects the growth of the overall economic development of each country (Vajic, 1989). It can be said that food systems are usually conceived as a set of activities ranging from production to consumption, often presented as a value chain (Posthumus et al., 2018).

The aim of the work is to present and analyze the food system, and especially the segment related to the production of the most important agricultural products, as well as their consumption, based on which it will be seen whether there are pressures that threaten the ability to meet the nutritional needs of the global population. The analysis covers the period from 2012 to 2021.

Concept of the food system

The food system includes the production, processing, distribution and consumption of food as key components (European Commission, 2020). The integrity of the food industry profoundly affects the health of our bodies, as well as the health of our environment, our economy, and our culture. If our food systems fails, it will threaten our education, health, economy, as well as human rights, peace and security, with the most vulnerable will be those who are already poor or marginalized (Guterres, 2021).

Around the world, the adoption of unified consumption and production patterns approach in food systems is accelerating. The definition of food systems should accelerate progress in meeting the 2030 Agenda demands (von Braun et al., 2021).

The food system wheel/ representation has FAO's (Food and Agriculture Organization) main goals at its center, which include poverty reduction, food security and nutrition (Figure 1). They are embedded in the broader performance of the system, referring to the three dimensions of sustainability: economic, social and environmental (FAO, 2018).

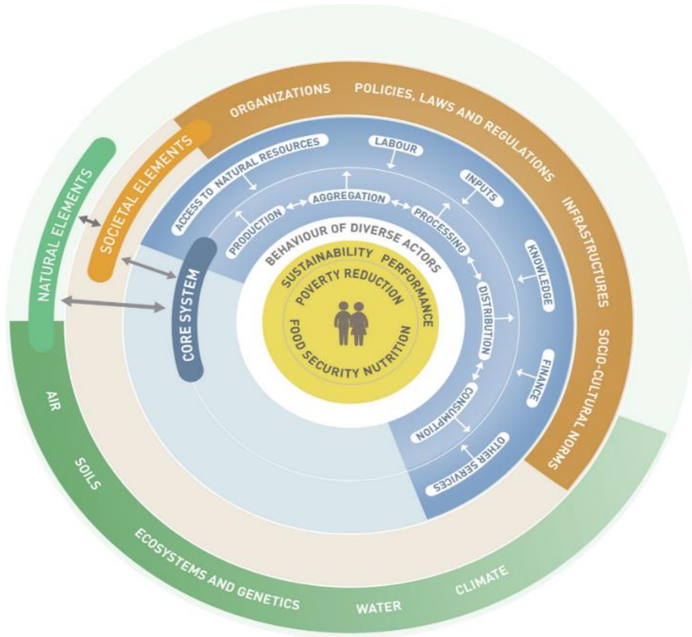

Figure 1. The Food System Wheel *(FAO, 2018)*

The food systems consists of all the people, institutions, environments, infrastructure and activities related to the production, processing, distribution, marketing, sale, preparation and consumption of food (Figure 2) and are interconnected with health, the environment, culture, politics and the economy (Fanzo et al., 2020, HLPE, 2020). Elements of the food supply chain include (HLPE, 2017):

1. Production - Agriculture and food production systems affect the availability and accessibility of food, as well as the quality and diversity of food. Dominant crops worldwide include: maize, rice, wheat, sugarcane, soybean, and palm oil. Among these, maize, wheat and rice account for over half of the global supply used for human food, animal feed, and other purposes.

2. Storage and distribution - Food that is not immediately consumed by producers must be either stored for later consumption or distributed. At this stage of the food supply chain, food safety and food quality losses and waste have a significant impact on nutrition quality.

3. Processing and packaging - These processes contribute to preventing and extending the shelf life, increasing the bioavailability of nutrients, improving sensory characteristics and functional properties of food, destroying microbes and toxins transmitted through food, and enhancing food safety.

4. Retail and markets - Once food is processed, it is moved to formal or informal markets that may be close to or far from communities and households. The rapid expansion of supermarkets and fast food chains is influencing consumer behavior and food consumption patterns. It is estimated that 51% of global food sales are

purchased through supermarkets and hypermarkets. Food sales through these channels are growing at a rate of 2% per year (Gladek et. al., 2016).

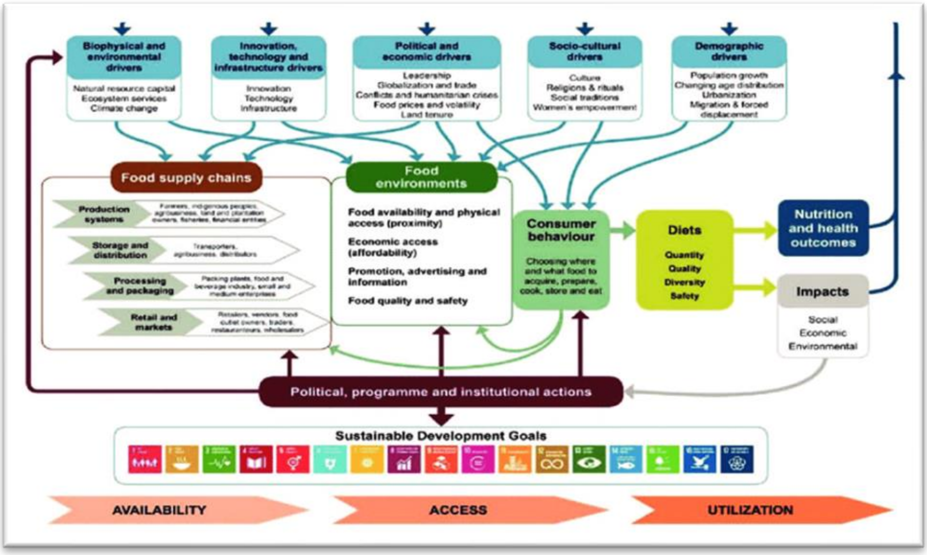

Figure 2. Food system framework

Source: UN High Level Panel of Experts Report on Food Systems and Nutrition 2017

Food waste is a major problem that arises due to financial, managerial, technical, and health-safety constraints in food production at all stages of the post-harvest supply chain. It leads to nutritional deficiencies in the population, economic losses, and negative environmental impacts (Food Drink Europe, 2016; Milutinović, 2012). In 2011, the FAO published the first estimates of global food waste. A study estimated that one-third of the food produced worldwide for human consumption goes unused each year, with much higher per capita food waste in industrialized countries compared to developing countries (FAO, 2013; Gustavsson et al., 2011). In developed countries, the problem of food waste begins with excessive production, while in underdeveloped countries, poor infrastructure, inadequate storage conditions and a lack of adequate processing capacity are the cause of large food losses (Stuart, 2009). There are five different stages of food loss in the food supply chain, which are identical for products of plant and animal origin (Table 1).

Table 1. Food losses by stages of the supply chain

Supply chain phase	Plant production	Livestock production
Production	Mechanical damage and/or spillage during harvesting or sorting	Death during breeding, reduction of milk production due to disease
Handling and storage	Spillage and degradation during handling, transport and storage	Death during transportation to the slaughterhouse, losses during storage, transportation
Processing	Spillage and losses during processing, washing, peeling, cutting, cooking	Losses during industrial treatments (pasteurization), trimming (removal of skin, fat) and the like
Distribution	Losses in markets (manipulation, prices, inadequate storage)	
Consumption	Losses at the level of households and food service facilities	

Source: Adapted by the author based on Gustavsson et al., 2011.

The existing food system (production, transport, processing, packaging, storage, retail, consumption) feeds the vast majority of the world's population and supports the existence of over 1 billion people. However, an estimated 821 million people suffer from undernourishment, 151 million children under the age of five experience stunted growth, 613 million women and girls aged 15 to 49 suffer from iron deficiency, and 2 billion adults are overweight or obese (Mbow et al., 2020, Kılıç, 2022). All of this indicates that the food system is under significant pressure due to both climate and non-climate-related changes (e.g., population and income growth, demand for animal-derived products) (FAO, UN, 2015).

The results related to the growing food production achieved by the Green Revolution indicated that food insecurity and the hunger problems are not primarily caused by insufficient food production as by the low purchasing power of certain social groups (Božić and Papić, 2019).

Global trends in food production

Food production needs to be at a satisfactory level in quantity and quality in order to sustain the global population. It is necessary to reduce food waste decrease excessive consumption beyond what is necessary for a healthy life (Berners-Lee M., et al., 2018). Stable agricultural production allows countries to better forecast food availability (Božić and Nikolić, 2020).

Cereal production

Cereal production is one of the most significant sources of food both for the population and for livestock production. Cereals occupy the largest area of arable land, approximately 47% (Gladek et al., 2016). The average global cereal production from 2012 to 2021 is around 3 billion tons, with corn, wheat, and rice dominating the total cereal production. The yield of maize, wheat and rice varies depending on climatic conditions. The yield is influenced by the variety and cultivation technology, as well as the adequate application of agrotechnical measures. The average yield of corn is around 5.62 t/ha, increasing at a rate of 2.16%. The average yield of wheat is around 3.38t/ha with a growth rate of 1.36%. The achieved yield of rice is about 4.60t/ha, increasing at a rate of 0.58%. Maize production averaged 1.1 billion tons, wheat production around 740 million tons, and rice production around 750 million tons from 2012 to 2021 (Table 2).

Table 2. Total area and production of the most important cereals in the world in the period from 2012 to 2021.

Year	Maize				Wheat				Rice			
	Area	Yield	Production		Area	Yield	Production		Area	Yield	Production	
	(ha)	(t/ha)	t	Index	(ha)	(t/ha)	t	Index	(ha)	(t/ha)	t	Index
2012	180.367.174	4,85	875.548.703	100	217.917.933	3,09	673.736.909	100	160.854.022	4,52	727.680.664	100
2013	187.557.426	5,42	1.016.799.083	116	218.700.194	3,25	710.169.468	105	163.128.502	4,48	731.770.430	101
2014	186.492.181	5,58	1.040.718.155	119	219.755.320	3,32	728.757.761	108	162.253.249	4,51	731.417.050	101
2015	191.056.099	5,51	1.053.891.010	120	223.335.832	3,32	741.845.269	110	160.509.412	4,57	732.898.369	101
2016	194.262.790	5,78	1.123.728.793	128	219.156.976	3,41	748.432.483	111	161.379.058	4,57	737.089.267	101
2017	198.506.330	5,74	1.139.704.589	130	218.288.892	3,54	772.305.496	115	163.480.266	4,59	751.120.236	103
2018	195.423.561	5,75	1.124.172.165	128	213.828.044	3,42	732.235.584	109	163.887.845	4,64	761.025.481	105
2019	194.555.227	5,85	1.137.617.353	130	215.693.643	3,54	764.063.333	113	160.518.465	4,69	753.286.401	104
2020	199.994.407	5,81	1.162.997.554	133	217.898.510	3,47	756.949.628	112	163.092.574	4,72	769.227.953	106
2021	205.870.016	5,88	1.210.235.135	138	220.759.739	3,49	770.877.072	114	165.250.620	4,76	787.293.867	108
Difference	25.502.842	1,03	334.686.432	-	2.841.806	0,4	97.140.163	-	4.396.598	0,24	59.613.203	-
Growth rate (%)	1,48	2,16	3,66	-	0,14	1,36	1,51	-	0,30	0,58	0,88	-

Source: Author's calculation based on FAO database, http://www.fao.org/faostat/en/#data/QC

Production of meat, milk and eggs

Meat is an important source of nutrition for many people around the world, and in recent years the global demand for meat has been steadily increasing. Dynamic growth is particularly associated with the production of poultry meat. Observing the period from 2012 to 2021, there is a constant growth trend and the average production of meat in the world is around 330 million tons. Poultry and pork dominate the total world meat production in the period from 2012 to 2021, with an average of 123 million tons and 118 million tons, respectively (Table 3). Poultry production in 2021 increased by 29% compared to the baseline, at a rate of 2.84%. Additionally, the production of beef, sheep and goat meat, as well as milk and eggs, shows a growth trend, with slight oscillations occurring in the production of pork meat in 2019 and 2020, when production decreased by approximately 4% compared to the baseline year.

Table 3. Total production of meat, milk and eggs in the world, in the period from 2012 to 2021.

Year	Pork		Poultry		Beef		Sheep and goat meat		Milk		Eggs	
	Production		Production		Production		Production		Production		Production	
	t	Index	t	Index	t	Index	t	Index	t	Index	t	Index
2012	112.296.770	100	107.243.169	100	69.379.540	100	13.698.513	100	755.170.148	100	72.581.812	100
2013	114.252.420	102	110.293.097	103	70.676.984	102	14.059.660	103	773.931.597	102	74.262.125	102
2014	116.348.510	104	113.399.662	106	71.188.770	103	14.429.260	105	800.328.759	106	75.849.088	105
2015	118.609.150	106	117.581.053	110	70.859.730	102	14.915.738	109	814.505.693	108	78.109.869	108
2016	117.895.880	105	120.733.785	113	67.996.350	98	15.183.239	111	823.674.448	109	80.290.220	111
2017	118.806.240	106	124.705.064	116	72.610.344	105	15.376.156	112	844.909.628	112	84.752.536	117
2018	119.073.656	106	128.275.725	120	74.484.904	107	15.526.263	113	867.394.020	115	86.235.678	119
2019	108.184.120	96	133.801.560	125	76.488.910	110	15.776.161	115	886.058.731	117	90.155.560	124
2020	108.252.150	96	137.029.230	128	75.877.000	109	16.105.014	118	914.475.798	121	93.339.903	129
2021	120.372.130	107	137.979.965	129	76.768.270	111	16.357.614	119	918.162.582	122	92.562.542	128
Difference	8.075.360	-	30.736.796	-	7.388.730	-	2.659.101	-	162.992.434	-	19.980.730	-
Growth rate (%)	0,77	-	2,84	-	1,13	-	1,99	-	2,19	-	2,74	-

Source: Author's calculation based on FAO database, http://www.fao.org/faostat/en/#data/QC

Trends in population and food production

Globally, the volume of agricultural production in the world has a positive trend and follows the growth of the population. The growth rate of the number of inhabitants in the world in the period 2012-2021 was 1.11%, while slightly lower growth rates were achieved in basic bread grains (wheat 1.51% and rice 0.77%) (Table 4). The production of pork meat in the world recorded trend in the observed period of 0.77%, although pork meat was the most demanded globally, until the production of poultry meat rapidly increased by as much as 2.84%.

Table 4. Growth rates of the total number of inhabitants and production of the most important agricultural and food products in the world in the period from 2012 to 2021.

Growth rate in%	Population	Cereal production			Meat production				Milk production	Eggs production
2012-2021.		Maize	Wheat	Rice	Pork	Poultry	Beef	Sheep and goat meet		
World	1,11	3,66	1,51	0,88	0,77	2,84	1,13	1,99	2,19	2,74
Asia	0,92	3,08	1,15	0,53	-0,12	3,57	2,29	2,54	4,02	3,22
Africa	2,53	3,26	1,90	2,79	3,77	4,76	1,03	2,20	1,11	1,08
North America	0,73	3,73	-3,08	-0,46	2,03	2,06	0,97	-0,99	1,38	2,01
South America	0,88	4,91	2,11	0,80	3,30	2,34	0,63	1,21	0,69	4,24
Central America	1,12	2,25	0,03	2,06	3,33	3.51	1,89	0,72	1,81	2,84
Europe	0,09	4,44	3,64	-1,67	1,35	1,69	-0.83	3,13	0,89	0,58
Oceania	1,65	-2,53	0,70	-8,01	1,67	2.35	-0,28	0,90	0,77	2,69

Source: Author's calculation based on FAO database, http://www.fao.org/faostat/en/#data/QC

With the increase in the number of inhabitants, that is, the purchasing power of consumers and other important factors, the consumption of meat in the world is growing relatively quickly. Purchasing power affects the choice of food that will meet the needs of the population in certain regions of the world. Different income levels and different income growth projections among countries will lead to different dietary patterns in the next decade (OECD/FAO, 2020).

Conclusion

Food systems include all processes used in food production from growing, harvesting, packaging, processing, transportation, marketing, consumption and disposal of food waste. The food system has a taskto meet the nutritional needs of the population, and the adoption of a food systems approach to unify consumption and production patterns is accelerating around the world. Therefore, an adequate food system should accelerate progress in meeting the goals of the 2030 Agenda, which enable the development of future generations, through sustainable development, production and consumption as well as through sustainable environmental protection. As the basic components of the food system are the production and consumption of agricultural and food products, the work follows the global trends in the production of the most important cereals (wheat, maize and rice) and types of meat (pork, poultry, beef, sheep and goat), milk and eggs, which determine the diet. Average production of cereals in the world in the period from 2012 to 2021, amounts to about 3 billion tons, while meat production is constantly increasing and is around 330 million tons.

The food system is under significant pressure to ensure that future generations meet their food needs, bearing in mind that the world's population is increasing. If there was an improvement in the food system in food production and sustainable development and more even distribution and consumption, the current food waste and malnutrition of the population would be reduced in this way throughout the world.

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THE IMPORTANCE OF THE FISCAL RELIEF IN THE PRODUCTION OF WHEAT AND CORN IN THE FUNCTION OF PROTECTING THE FOOD MARKET IN THE REPUBLIC OF CROATIA

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Abstract

Food production is one of the world's biggest problems. Statistics record a dizzying increase in the world's population, with a particularly pronounced trend in the underdeveloped countries of the world, which are also the weakest food producers, which contributes to an uneven ratio in the production of components that are components of everyday food products. The goal of this bio paper is to make a market analysis of the production of wheat and corn for the market of the Republic of Croatia as inputs from which ready-made food is produced and to point out the importance of fiscal relief of production. This research will show how important it is to implement a sustainable production management policy to reduce production costs. The emphasis of the research was focused on models for reducing the tax burden on businesses to raise the level of market competitiveness. In the research, a supply and demand curve for wheat and corn was formed based on current prices and production volumes, and changes were shown when the tax burden is reduced. Adequate management of the production process must be put into the function of protecting the domestic market. In this way, it is possible to meet domestic needs and create conditions for the expansion of food production. Considering the current market circumstances, this topic is given great importance, since the available data show that the purchasing power of the majority of the population in the country is declining, that is, food is becoming more expensive and scarcer.

Key words: Wheat, corn, food, market, supply.

Introduction

Production resources represent the inputs used in the production process. Economic goods are rare because there are fewer of them than human needs (that is, things or services that are desired and rare), and therefore, they represent the subject of economic science (Jones, 1965). The definition of the economy refers to the most efficient use of resources, i.e. the realization of the best choice for their use, which means that economics solves two key problems (Saxsenian, 1994):

- scarcity (absence) of resources and
- choice (economic decisions).

The problem of scarcity manifests itself in the continuous gap between the volume of satisfied and unsatisfied desires, which is reduced by economic progress, but never resolved. The scarcity of goods and services, which satisfy numerous wants, needs and aspirations, stem from the scarcity of resources (Porter, 1990). Resources are all material and immaterial sources of wealth, whether found in nature (raw materials) or produced by human labour (buildings, equipment, infrastructure; Sawant., 2010). Therefore, the treatment of scarce resources and the problem of choosing between alternative uses of these resources, shows: economics as a science of rational choice, which discovers and improves the rules that guide people in their rational economic behaviour (Blanchard, 2005). Deciding on a choice presupposes a comparison of benefits and harms, income and expenses, costs and profits, i.e. that the benefits of a given choice are greater than the cost, and that people should improve their economic situation by making a given choice. In economic terms, all resources used to produce output (products and services) are considered factors of production. The following three factors of production are most often mentioned in the literature (Davis et al., 2005):

- natural resources,
- workforce and
- capital.

Natural resources as the first factor of production represent resources that are found in nature. The Republic of Croatia is a country that has a large number of natural resources at its disposal, so it has an advantage over other countries. Labour is the second factor of production. Work can be characterized as the effort a person puts in to solve a work task. Work in the free market means any job for which a salary is paid. Persons who can work represent the labour force. Labour resources are the active population of society with their knowledge and abilities (Davis et al., 2005). Capital is the third factor of production. Capital can be physical or human capital. Physical capital is a very important factor in production because it reduces the need for labour, increases productivity, and improves the saving of money and time. Human capital is all employees, i.e. the workforce who perform a job using their skills, knowledge, and experience (Krueger, 2009). By combining these resources, new production values are created. In agricultural production, the choice of production largely depends on the availability of natural resources and costs. Producers who produce in areas that have plenty of natural resources will use more labour in the production process, that is, they will produce with a lower consumption of that resource and vice versa. The cost of labour, capital and technology represent the cost price of the product (Samuelson, 1948). Considering the large areas of arable land that belong to the category of high-quality arable soil and quality arable soil, which, according to the Ministry of Agriculture, is 1.16 million hectares, the Republic of Croatia has all the prerequisites for the production of agricultural products as the main components in food production. Currently, food becomes a limited resource necessary for human existence. The development and progress of modern technology enables the unused resources of the country in the world, with the cooperation of knowledge and technical aids, to be brought to exploitation. Scientific progress in chemistry, biology, agronomy, etc. will certainly enable the emergence of new sources of food. The business climate in the market of the Republic of Croatia is very rigid, that is, it is slow to adapt to current market shocks. The future brings prosperity, but also some negative tendencies such as environmental pollution, war conflicts, the presence of inflation, rising prices of production inputs, etc. The Republic of Croatia is an active participant in these processes. It is necessary to intensify agricultural production and, with macroeconomic and trade policy measures, influence the change in the structure of existing production, the return of young people and create conditions for quality and affordable food production, that is, endure to reduce the rigidity of business (Lynggaard, 2006). High VAT increases the price, reduces the turnover of products, and increases daily living costs (Sabolić, 2013), which results in a reduced coefficient of turnover of goods on the market. However, the positive effects that are realized can hardly compensate for the negative effects of the fiscal policy expressed through high taxes of VAT, product tax, and income tax. These are prerequisites for strategic development goals. The goal of this paper was to point out the importance of fiscal relief of production to reduce the rigidity of business, based on the market analysis of wheat and corn production for the market of the Republic of Croatia.

Material and methods

In this research, data from the Ministry of Agriculture of the Republic of Croatia (Annual Report on the State of Agriculture in 2021), Eurostat and the State Statistical Office for the year 2021 related to wheat and corn were used, and the key terms are the volume of production, price movements, trade and taxation. The analysed data are presented in the following Table 1

Table 1. The production of wheat and corn in 2021 in Republic of Croatia (Ministry of Agriculture of the Republic of Croatia)

Components	**wheat**	**corn**
Total production in tons	961.940	2.242.119
Increase, or decrease in production compared to the previous year +/-	+13,2%	-7,7%
Share of the Republic of Croatia in the EU in %	0,7	3,2
Share in total plant production in %	55	27
Self-sufficiency in %	174	177
Trade balance +/-	+437.000	+888.000
Live head price per kg in EUR	0,21	0,23
Increase decrease in price compared to the previous year +/-	+3,1	+3,6
Average value added tax in %	13	13
Average product tax in %	18	18
Average income tax in %	5	5

To determine economic policy measures, it is necessary to look at the demand and supply of wheat and corn. Given that every sector faces limitations in terms of production volume, resource spending, and profit maximization, it is necessary to take a detailed look at all types of limitations that are imposed. Due to all the above, the demand curve and the supply curve for wheat and corn will be formed below, and based on these data, the correlation calculation will show the intensity of the connection between production and taxation, and finally, the regression model will show how much the change of one variable affects the change of another variable.

Results and discussion

The data in Table 1 show that wheat production occupies a small share of the total European production, i.e. the values are below 1%. Maize production is represented by a larger share of over 3%. Furthermore, observing the share of wheat production in the total plant production, it is evident that wheat represents 27%, but corn occupies 55% of the share of plant production. The self-sufficiency of both crops is 55%, which is positively reflected in the net export balance. One of the main factors contributing to these figures is the large area of arable land and the high level of disbursed funds through support measures of EUR 70,000,000.00. Funds were paid for investments in physical assets, i.e. building capacities for housing agricultural products, procurement of machinery, construction of drainage systems, new plantations, etc. The above data support the fact that the agricultural policy is being implemented expediently and efficiently. According to Eurostat data, the Republic of Croatia has an almost 50% higher VAT tax rate compared to the EU average and a 40% higher tax rate on products compared to the EU. Taxes greatly burden both citizens and the business sector and create an unfavourable business climate, which leads to migration of both the population and industry to countries where the business climate is more favourable.

According to the data from Table 1, a curve of demand and curve of supply for wheat and corn was formed. The quantity was measured in thousands of tons.

Table 2. Calculation of the selling price of wheat and corn

Demand curve		**Supply curve**	
Wheat	D = 995 – 25p	Wheat	S = 905 + 20p
Corn	D = 990 – 10p	Corn	S = 935 + 20p

**D – demand, S – supply, P – price*

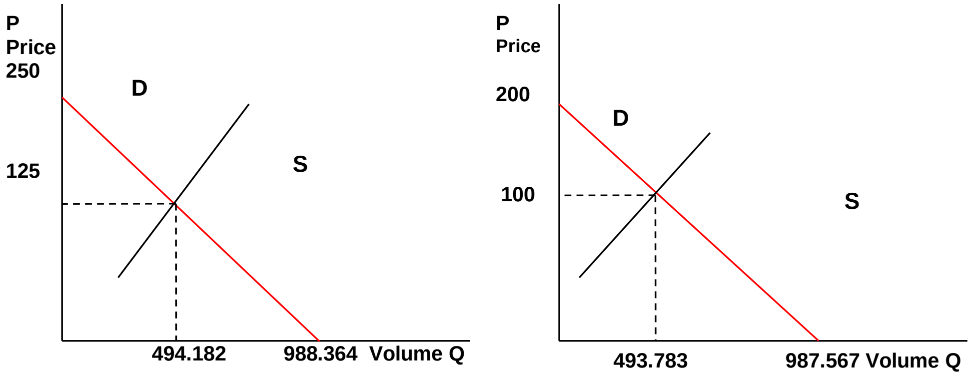

Figure 1. Supply and demand curve and optimal point for wheat and corn

Based on the above functions, the price of wheat was formed, which is 0.26 euro/kg, while the average price of corn is 0.24 euro/kg. When the value of the average price is included in the equation, it is obtained that according to the current prices, the need for wheat is 988,364 tons, and for corn 987,567 tons. At the intersection of two curves there is a balance point (Figure 1).

However, on the one hand, the mentioned prices are not competitive in the European market, and on the other hand, they have a destructive effect on agricultural production. One of the ways to make the unit price more competitive is to lower the fiscal levies that burden it. If we start from the assumption that the VAT on agricultural products will be reduced successively to 5%, the regression model will show in which direction the production volume and production costs will move (Figure 2).

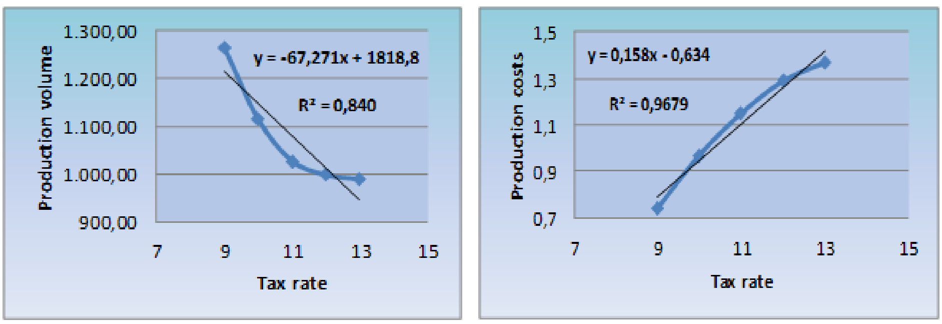

Figure 2. Regression model of the relationship between the tax rate and the volume of wheat production and the tax rate and wheat production costs

The regression model Y = bx + a in Figure 2 on the left shows that if the tax rate were to increase by 1%, we can expect a decrease in the total volume of production by 67,271 tons. The downward trajectory of the curve shows that each percentage reduction in the tax rate causes an average increase in the volume of production by 8%. The regression model Y = bx + a in Figure 2 on the right shows that if the tax rate were to increase by 1%, it would cause an increase in production costs by 0.015 per kg. The upward trajectory of the curve shows that each percentage increase in the tax rate causes a percentage increase in production costs by over 9% on average.

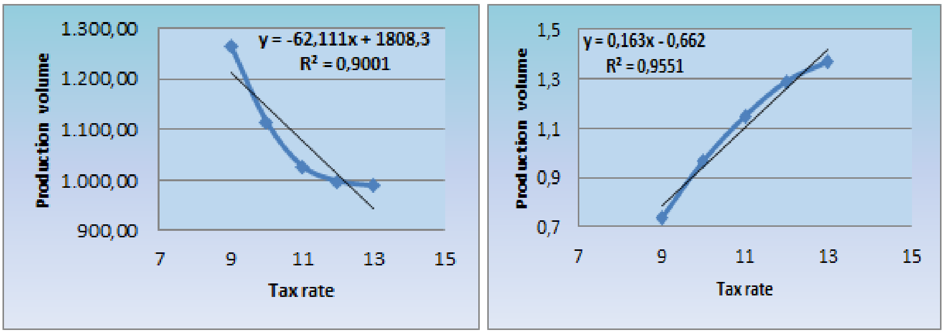

Figure 3. Regression model of the relationship between tax rate and production costs in wheat and corn production

The regression model Y = bx + a in Figure 3 on the left shows that if the tax rate were to increase by 1%, we can expect a decrease in the total volume of production by 62,111 tons. The downward trajectory of the curve shows that each percentage reduction in the tax rate causes an average increase in the volume of production by 9%.

The regression model Y = bx + a in Figure 3 on the right shows that if the tax rate were to increase by 1%, it would cause an increase in production costs by 0.016 per kg. The upward trajectory of the curve shows that each percentage increase in the tax rate causes a percentage increase in production costs by over 9% on average.

Conclusion

The main purpose of the paper was to give a hypothetical overview of the trend of wheat and corn production at the current tax rate. The results of the research showed that, through support measures, financial resources are directed to the technological improvement of factors of agricultural production. This is one of the reasons why the price of wheat and corn does not deviate significantly from the market price. A decrease in the market price would stimulate the demand for wheat and corn on the domestic market, which would further enable additional production in the processing sector. Given the sufficiency of wheat and corn production, the produced surpluses are exported, which gives a positive trade balance. Furthermore, any further reduction in the tax rate of 1% would cause an increase in the volume of wheat and corn production by an average of 9%. The results of the research showed that it is very important to maintain a continuous interaction between agricultural policy and fiscal policy in order to encourage production in the secondary and tertiary sectors. Considering the openness of the market of the Republic of Croatia, and the free movement of goods, works and services, it is necessary to focus on attracting investments through an active investment policy, but it is necessary to make the tax system more flexible, that is, to correct the level of tax rates in such a way that they are attractive to investors.

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PROFIBILITY DETERMINANTS OF MEDIUM-SIZED AGRICULTURAL COMPANIES IN THE AP VOJVODINA

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Abstract

The paper analyzes the determinants of profitability of medium-sized agricultural companies that operated in AP Vojvodina from 2014 to 2021. Using panel regression analysis, the influence of various microeconomic and macroeconomic determinants on profitability, measured by the return on assets and the return on equity, was examined. The following indicators were observed as microeconomic determinants of profitability: liquidity, financial leverage, indebtedness, tangibility of assets and turnover ratio of total business assets. Indicators of the gross domestic product and inflation were observed as macroeconomic determinants of profitability. Based on the results of the research, it was determined that the profitability of agricultural companies, measured by the return on assets, is significantly influenced by indebtedness, the turnover ratio of total assets and the gross domestic product. The profitability, measured by the return on equity, is statistically significantly influenced by indebtedness, the tangibility of assets, the turnover ratio of total business assets and the gross domestic product.

Key words: Profitability, agricultural companies, panel regression analysis, AP Vojvodina.

Introduction

Profitability is one of the most frequently used indicators of the success of a company's operations. Depending on the subject of observation, it shows the ability of the company, i.e., economic branches or the entire economy to generate profit. For the reasons mentioned, this indicator is very significant for all interested parties in business (Tekić et al., 2022). When analyzing the success of a company's operations, it is necessary to take into account other determinants that can have an impact on profitability in addition to profitability. These determinants are divided into microeconomic and macroeconomic. Microeconomic determinants are those that are influenced by the company itself, usually referring to various financial indicators of the company itself, while macroeconomic determinants are those that the company has no influence on, but they can certainly affect its operations. In order to conduct a detailed analysis of profitability, it is necessary, in addition to individual company analyses, to perform it at the sector level as well. In this regard, agricultural production as the primary sector carrier in AP Vojvodina is of strategic importance for the entire economic system, and this paper will analyze the determinants of the profitability of agricultural companies. The subject of the research are medium-sized agricultural companies, which operated on the territory of AP Vojvodina in the period from 2014 to 2021. Medium-sized companies represent the carrier of the agricultural sector in the Republic of Serbia, and therefore also in AP Vojvodina (Tekić, 2022), and were accordingly to that chosen for this analysis. The aim of the research is to evaluate the profitability of medium-sized agricultural companies, measured by the return on assets and the return on equity, as well as to determine the influence of microeconomic and macroeconomic determinants on the profitability of the observed companies.

Literature Review

A large number of authors in the world were engaged in the research of determinants affecting the profitability of companies from the agricultural sector. Some of them observed only microeconomic (internal) determinants of profitability, while others also analyzed the influence of macroeconomic (external) determinants on profitability. One of the first studies on this topic was conducted by Goddard et al., (2005) who examined the influence of internal determinants on the profitability of companies from the manufacturing and service sectors in Belgium, France, Italy and Great Britain. The sample of this research included 12,508 companies, for the period from 1993 to 2001. Using a panel regression analysis, the authors determined that there is a negative impact of company size on profitability, that market share has a positive impact, in most observed countries, which is stronger in the manufacturing than in the service sector, that the debt ratio has a negative impact, while liquidity has a positive impact impact on the profitability of the observed companies in all countries. Asimakopoulos et al., (2009) analyzed the profitability factors of Greek companies in the period from 1995 to 2003. The results of this research showed that the size of the company, sales growth and investments have a statistically significant and positive impact on the profitability of Greek companies, while financial leverage has a negative impact. Chandrapala and Knapkova (2013) investigated internal determinants influencing the financial performance of companies in the Czech Republic. The sample consisted of 947 companies that operated from 2005 to 2008. Panel regression analysis determined that the profitability of the observed companies has a positive statistically significant impact on the size of the company, sales growth and capital turnover ratio. The debt ratio and the inventory turnover ratio were singled out as significant factors that have a negative impact on the profitability of the analyzed companies. Suardi and Noor (2015) analyzed the impact of capital structure on the financial performance of agricultural companies in Indonesia. The sample of this research consisted of 16 agricultural companies, which operated in Indonesia in the period from 2010 to 2014. Using multiple regression, the authors examined the influence of financial leverage and debt ratio on each indicator of profitability and came to the conclusion that the indicators of capital structure have a statistically significant influence on the profitability of the observed companies only in the case when it is expressed by the rate of return on capital, while both indicators have a negative impact on profitability. Jacob and Collins (2016) in their study, analyzed the profitability factors of agricultural companies in Kenya. 7 agricultural companies were analyzed in the period from 2006 to 2014, statistical analysis was performed using multiple regression. The results of this research showed that liquidity and company size have a statistically significant and positive impact on the profitability of agricultural companies in Kenya, while the tangibility of assets has a statistically significant negative impact on the profitability of the observed companies. An analysis of determinants influencing the financial performance of agricultural companies from China was conducted by Liu et al., (2020), the sample included 39 companies that were analyzed for the period from 2013 to 2018. Based on the results of the regression analysis, the authors determined that the observed dependent variables, i.e. the performance of agricultural companies has a statistically significant influence on the size of the company, the ratio of short-term liabilities and assets, sales rate, financial leverage, intensity of capital and exports. Andrašić et al., (2018) analyzed the factors affecting the profitability of medium and large agricultural companies in AP Vojvodina in the period from 2006 to 2015. The sample included 420 companies. By applying multiple regression methods, the authors came to the conclusion that all observed factors have a statistically significant impact on the profitability of observed companies. Profitability is negatively influenced by company size and debt ratio, while all other factors have a positive impact on profitability. Tekić et al., (2022) analyzed the factors affecting the profitability of small agricultural and food companies that operated in the territory of the Republic of Serbia in the period from 2010 to 2019. Using a panel regression analysis, the authors concluded that the profitability of agricultural companies has a positive and statistically significant influence on the turnover ratio of current assets, the turnover ratio of receivables from customers and the gross domestic product, while a significant and negative influence is on indebtedness, the tangibility of assets, the turnover ratio of total assets and inflation.

Research Methodology

Sample

The research is based on data from the company's financial reports. Based on data taken from the Agency for Business Registers, at the end of 2021, 1,950 agricultural companies were operating in AP Vojvodina. Out of the total number of agricultural enterprises, 84 were medium enterprises. First of all, companies that did not operate during the time period determined for the purposes of this research were excluded from the basic set. Also, those companies that did not regularly submit financial reports and those that are in bankruptcy or liquidation are excluded. In accordance with the above, a proportional sample was selected from the number of remaining companies against their participation in the basic set, and after that, companies with extreme values of profitability indicators were excluded from the sample. 41 companies remained in the sample used in the analysis.

Variables

As microeconomic determinants of profitability, various financial indicators of the company's business success were used, which were calculated on the basis of data from the financial reports of observed agricultural and food companies. The gross domestic product growth rate and inflation were observed as macroeconomic determinants of profitability. The list of variables used to form panel regression models is shown in Table 1.

Table 1. List of variables

Variable	Notation	Measurement	Predicted sign
Return on assets	ROA	Net income/Average total assets	/
Return on equity	ROE	Net income/Total equity	/
Liquidity	LIQ	Current assets-Inventories/Short-term liabilities	+/-
Financial leverage	LEV	Total liabilities/Total capital	+/-
Indebtedness	DEBT	Total liabilities/Total assets	+/-
Tangibility of assets	TANG	Fixed assets/Total assets	+/-
Total asset turnover ratio	TOAT	Sales revenue/Average total assets	+/-
Gross domestic product	GDP	Growth rate of gross domestic product	+/-
Inflation	INF	CPI growth rate	+/-

Source: Authors' review

Methodology

In order to assess the impact of microeconomic and macroeconomic determinants on the profitability of medium-sized agricultural companies that operated on the territory of AP Vojvodina in the period from 2014-2021. the method of panel regression analysis will be used. Panel data represent a combination of comparative data and time series, ie. they provide both a temporal and a spatial dimension.

The most commonly used panel data models are linear models, which represent a kind of combination of comparative data and time series. In its general form, a panel data regression model can be displayed using the following function:

$$y_{it} = \beta_{1it} + \sum_{k=2}^{K} \beta_{kit} x_{kit} + u_{it}, i = 1, \dots, N; t = 1, \dots, T; k = 1, \dots, K.$$

Where: y_{it}– value of the dependent variable for the ith unit of observation in period t; x_{kit} – value of the kth independent variable for the ith unit of observation in period t; β_{kit} – regression parameters, which in the general form of a panel data model are variable by observation units and by time periods; u_{it} – random error, which has an arithmetic mean equal to one and a constant common variance for each i and t.

For all formed models, the basic assumptions for the application of panel data were first checked, i.e. The existence of multicollinearity, heteroskedasticity, autocorrelation and dependence of comparative data was tested in order to select the final model specification.

In order to examine the influence of microeconomic and macroeconomic determinants of profitability of medium-sized agricultural companies, regression models were created that have the following form:

$$\mathrm{ROA}_{it} = \beta_{it} + \beta_{1\,\mathrm{LIQ}} + \beta_{2\,\mathrm{LEV}} + \beta_{3\,\mathrm{DEBT}} + \beta_{4\,\mathrm{TANG}} + \beta_{5\,\mathrm{TOAT}} + \beta_{6\,\mathrm{GDP}} + \beta_{7\,\mathrm{INF}} + u_{it}$$

$$\mathrm{ROE}_{it} = \beta_{it} + \beta_{1\,\mathrm{LIQ}} + \beta_{2\,\mathrm{LEV}} + \beta_{3\,\mathrm{DEBT}} + \beta_{4\,\mathrm{TANG}} + \beta_{5\,\mathrm{TOAT}} + \beta_{6\,\mathrm{GDP}} + \beta_{7\,\mathrm{INF}} + u_{it}$$

Where i is the label for each company (i= 1,2,3…,n), and t is the label for each year (t= 1,2,3…,8).

Results and discussion

Descriptive statistics

The following table presents the results of descriptive statistical analysis for the indicators of small agricultural companies (Table 2).

Table 2. Descriptive statistics for business indicators of medium-sized agricultural companies from the AP Vojvodina, from 2010 to 2019

Indicator	**Median**	**Minimum**	**Maximum**	**Standard deviation**
ROA	0,032	-0,238	0,288	0,055
ROE	0,061	-5,433	611,038	33,709
LIQ	1,295	0,180	32,210	2,535
LEV	0,650	0,020	8798,020	487,953
DEBT	0,392	0,023	1,094	0,241
TANG	0,592	0,000	0,961	0,321
TOAT	0,001	0,000	1334,564	135,711
GDP	2,7	-1,6	7,5	2,783
INF	1,9	1,1	4,1	0,925

Source: Authors' calculation

The median value of the ROA indicator, in the observed period, was 3.2%. The median value of the ROA indicator of 3.2%, in the case of medium-sized agricultural companies, indicates the low level of profitability of these companies, because it does not reach the limit of 5%, which is considered to represent good profitability. The median value of the ROE indicator in the observed period was 6.1%, which is also below the reference limit of 10%, and can be considered low profitability. The liquidity indicator had a median value of 1.29, which indicates the company's ability to settle its short-term obligations using current assets. The median value of financial leverage is 0.65, which indicates the dominant participation of capital in liabilities. The median value of the indebtedness indicator is 0.39, this value shows that 39% of the company's assets are financed from debt, while the remaining 61% are financed from own sources. The tangibility rate has a median value of 0.59, this rate shows that the share of fixed assets in total assets is 59%. The median value of the turnover ratio of total business assets is 0.001, this value suggests that each dinar invested in total business assets produced only 0.001 dinars of sales revenue. The median value of the gross domestic product in the observed period was 2.7%, and the average inflation rate was 1.9%. The lowest value of the rate of gross domestic product was recorded in 2014, when it was -1.6%, and the highest value in 2021 was 7.5%. The lowest value of inflation was recorded in 2016 (1.1%), and the highest value was recorded in 2021 (4.1%).

Assumptions testing

The basic assumption for the application of regression models is that the independent variables are not highly correlated with each other, i.e. it is assumed that there is no multicollinearity. For the observed independent variables, which were used in both regression models, a multicollinearity check was first performed (Table 3).

Table 3. Multicollinearity testing

Variable	VIF	TOL
DEBT	1.43	0.69
LIQ	1.39	0.72
INF	1.33	0.75
GDP	1.33	0.75
TANG	1.22	0.82
ROAT	1.03	0.97
LEV	1.03	0.97

Source: Authors' calculation

Based on the results of VIF, i.e., TOL (1/VIF) coefficients, it can be observed that for no variable VIF value is not higher than 5, that is, the value of TOL is not below 0.2, and it can be concluded that there is no problem of multicollinearity in the formed models.

In the next step, assumptions for the application of panel regression models related to the absence of heteroskedasticity, autocorrelation and dependence of comparative data were tested (Table 4).

Table 4. Tests of heteroskedasticity, autocorrelation and dependence of cross-section data

	Model 1		Model 2	
Test	**Test statistics**	**p-value**	**Test statistics**	**p-value**
Breusch-Pagan/Cook-Weisberg test	0.000	0.952	0.020	0.894
Breusch-Godrey LM tes	53.651	0,000	117.595	0.000
CD Pesaran test	9.460	0.000	2.514	0.011

Source: Authors' calculation

To test the existence of heteroscedasticity, the modified Breusch-Pagan/Cook-Weisberg test was applied, and based on the results of this test, it can be seen that the null hypothesis of homoscedasticity is accepted at the 1% significance level for both formed models. The presence of autocorrelation was tested using the Breusch-Godrey LM test and the presence of autocorrelation was confirmed in both formed models, at the 1% significance level. The results of Pesaran's CD test ($p<0.05$) show that there is a statistically significant dependence of the comparative data, that is, the existence of common factors that have an impact on the dependent variable in both formed models.

For the purpose of choosing an adequate model specification, the Hausman test is applied. Given the violation of the basic assumptions of the panel model, a modified Hausman test was applied to select an adequate model specification. The results of the Hausman test statistic of 48.66 ($p=0.000$) indicate that the initial hypothesis was rejected at the 1% significance level, i.e. that a fixed specification of individual effects was chosen for the first model. The results of the Hausman test statistic, for the second , of 7.41 ($p=0.285$) indicate that the random individual effects specification was chosen for the second model.

Regression models

In order to overcome the violation of the basic assumptions of the model, an alternative specification of the fixed effects model with corrected standard errors (PCSE - linear regression with panel-corrected standard errors) was applied. The results of the alternative specification are shown in the following table (Table 5).

Table 5. Estimated model of fixed individual effects for the profitability of medium-sized agricultural companies (Model 1)

ROA	Coefficient	Standard error	t-statistics	p-value
Konstanta	0,097	0,021	4,66***	0,000
LIK	0,001	0,001	0,81	0,424
LEV	-0,001	0,001	-0,92	0,364
ZAD	-0,119	0,035	-3,39***	0,002
TANG	-0,011	0,021	-0,49	0,625
ROPI	0,001	0,001	2,74***	0,009
GDP	0,003	0,001	3,50***	0,001
INF	-0,001	0,001	-0,28	0,780
n	41			
t	8			
N	328			
F test	50,521			
p-value (F)	0,000			

Source: Author's calculation

*Note: *** - level of significance 1%; ** - level of significance 5%; * - level of significance 10 %*

The panel regression model (Model 1) was formed based on data for 41 companies and a time period of 8 years, and the total number of observations was 328. Based on the results of the F-test, it can be concluded that the formed model is highly statistically significant (p<0 ,01).

Indebtedness, the turnover ratio of total assets and the gross domestic product stand out as significant determinants of profitability, expressed by the return on assets. With that, the turnover ratio of total assets and the gross domestic product have a positive impact, while indebtedness has a negative impact on profitability measured by the return on assets.

Also, for Model 2, due to the violation of the basic assumptions of the panel model, an alternative specification of the random effects model was applied, representing a model with corrected standard errors (PCSE - linear regression with panel-corrected standard errors). The results of this model are presented in the following table (Table 6).

Table 6. Estimated model of random individual effects for the profitability of medium-sized agricultural companies (Model 2)

ROA	Coefficient	Standard error	z-statistics	p-value
Konstanta	0,085	0,018	4,78***	0,000
LIK	0,001	0,001	0,02	0,982
LEV	-0,001	0,001	-0,29	0,773
ZAD	-0,072	0,023	-3,11***	0,002
TANG	-0,031	0,016	-1,86*	0,063
ROPI	0,001	0,001	3,95***	0,000
GDP	0,003	0,001	3,28***	0,001
INF	-0,002	0,002	-0,79	0,430
n	41			
t	8			
N	328			
χ^2	921,172			
p-value (F)	0,000			

Source: Author's calculation

*Note: *** - level of significance 1%; ** - level of significance 5%; * - level of significance 10 %*

The panel regression model (Model 2) was formed based on data for 41 companies and a time period of 8 years, and the total number of observations was 328. Based on the results of the F-test, it can be concluded that the formed model is highly statistically significant ($p<0,01$).

Indebtedness, tangibility of assets, the turnover ratio of total assets and the gross domestic product stand out as significant determinants of profitability, expressed by the return on equity. The turnover ratio of total assets and the gross domestic product had a positive, while indebtedness and tangibility of assets had a negative impact on profitability measured by the rate of return on equity.

Discussion

The indebtedness ratio has a significant negative impact on the profitability of the observed agricultural companies in both observed models, i.e. both when profitability is measured by the return on assets and when it is measured by the return on equity. That is, it can be expected that with the increase in indebtedness, there will be a decrease in the profitability of the company. This result is in agreement with the results obtained by Goddard et al., (2005), Andrašić et al., (2018), Chandrapala and Knapkova (2013), Suardi and Noor (2015) and Tekić et al., (2022). The tangibility of assets had a statistically significant and negative impact on the profitability of medium-sized agricultural enterprises from AP Vojvodina, only in the case when profitability was measured by the return on equity. Due to the higher share of fixed assets, it can be concluded that their inadequate management leads to a decrease in profitability. This result is in agreement with the result reached by Mijić and Jakšić (2017) in their research on the determinants of profitability of agricultural companies from Southeast Europe, as well as Jacob and Collins (2016). The turnover ratio of total assets had a positive and statistically significant impact on profitability, in both models, which means that an increase in this indicator can be expected to increase profitability, i.e. to manage the total assets of companies from this sector in an adequate manner. The gross domestic product had a positive and statistically significant impact on profitability, in both models, this result is expected considering that the mentioned rate grew during the research period. This result confirms the result reached by Tekić et al., (2022).

Conclusion

Based on the results of the research of medium-sized agricultural companies from AP Vojvodina that operated from 2014 to 2021, on a sample of 41 companies, it was determined that the average profitability measured by the return on assets was 3.2%, while the average profitability measured by the return on equity amounted to 6.1%.

Using panel regression analysis, the influence of microeconomic and macroeconomic determinants on the profitability of the observed companies was examined. The profitability of the company was measured using the return on assets and the return on equity, and in both cases it was determined that the level of indebtedness has a significant and negative impact on profitability. Also, it was observed that in both observed models, the turnover ratio of total assets and the gross domestic product have a positive and statistically significant impact on profitability, and with their growth in the future, profitability growth can be expected. The results of the panel regression model determined that the tangibility of assets has a significant and negative impact on profitability measured only by the return on equity. The negative influence of the tangibility of assets indicates that in the future the policy of managing fixed assets should be directed towards their reduction or better management.

The results of the research contribute to a qualitative overview of the state and prospects of the further development of medium-sized agricultural companies from AP Vojvodina to the Republic of Serbia. It is expected that the obtained results will be useful to company managers, creditors, as well as creators of agricultural policy in AP Vojvodina and the Republic of Serbia.

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APPLICATION OF THE PRECISION AGRICULTURE SYSTEM IN DIFFERENT CLIMATIC CONDITIONS

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Abstract

The evolution of agricultural technology has been significantly impacted by scientific advancements in genetics, chemistry, and robotics. However, the need to increase agricultural production has been primarily driven by the rapid growth of the global population. In recent years, precision agriculture systems that utilize data science and machine learning techniques have been developed to meet this need. Big data analytics have enabled decision-making processes in agriculture to become more data-intensive, and this study reviews the use of big data analysis in the industry. Through a review of the literature and analysis of examples from practice, we will analyze different systems of precision agriculture, their advantages, and disadvantages, and compare their application in different climatic conditions.

Key words: Precision agriculture, Technology, Machine learning, Robotics, Artificial Intelligence.

Introduction

Agriculture is a term that encompasses various methods used to produce food for human consumption and other goods by cultivating plants and raising domestic animals. It includes a wide range of activities, such as crop production, farming, vegetation management, mixed food production, and deforestation. The agricultural system is vital for supporting the global human population, and precision agriculture has significantly improved farming management and has the potential to continue transforming the industry.

With precision agriculture, farmers consider multiple resources, such as land and inputs, when implementing conservation techniques, pricing their crops, and planning for the long-term scale of their activities. The development of precision agriculture has been aided by scientific advancements in data collection strategies, data analysis, high-sensitivity identification, field activity, and accurate agriculture evaluation. These advancements have led to a wealth of data in agriculture, challenging researchers and farmers to find new ways to analyze and utilize data to improve decision-making processes. (Song, Ma, Li, Qi, & Liu, 2022)

Overview of different systems of precision agriculture

Precision agriculture encompasses a variety of systems and techniques that aim to optimize farming practices for increased efficiency and reduced waste. Some of the most common systems of precision agriculture include:

Geographic Information Systems (GIS)

Farm automation has been facilitated by technologies such as GPS, robotics, drones, and satellite monitoring, which are used for collecting GIS data. GIS is a software-based solution that collects, stores, validates, and displays data pertaining to specific locations on the surface of the Earth. By visualizing data, GIS enables farmers to identify trends and patterns, detect changes, and quickly address issues. GIS plays a crucial role in precision agriculture by gathering and analyzing extensive field data to facilitate informed decision-making. (GIS In Agriculture: Best Practices For AgriTech Leaders, n.d.)

GIS has the ability to display various types of data simultaneously on a single map, including roads, structures, and plants, making it easier for individuals to observe, study, and comprehend trends and interconnections. To implement targeted management practices, GIS uses spatial data to map and analyze soil, water, and crop data. GIS software displays spatial data through maps, which are created using different GIS technologies and then linked to relevant maps and data that are hidden from view. As a result, the map not only shows the location and overall health of crops but also considers other relevant factors such as terrain, soil type, and fertilization.

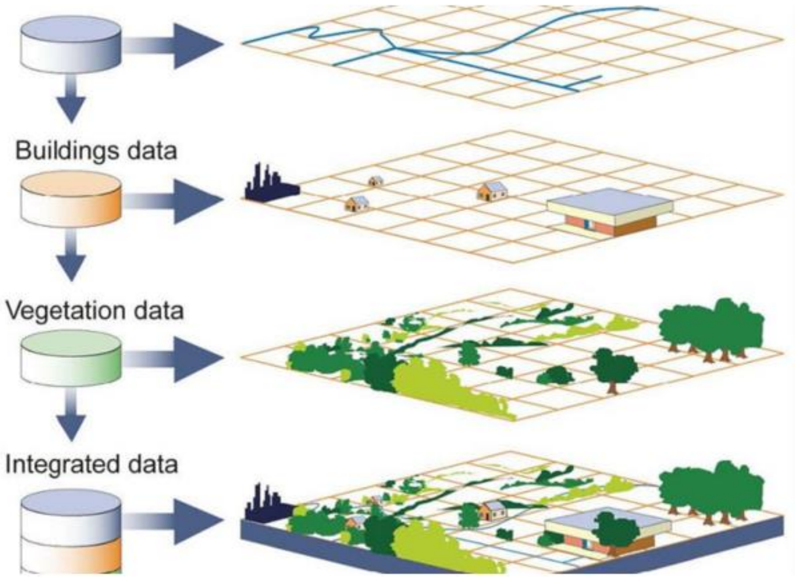

Figure 1. GIS (GIS (Geographic Information System))

Global Positioning System (GPS)

Precision agriculture also referred to as GPS-based agriculture, variable-rate farming, prescription farming, or site-specific farming, is an advanced farming technique that uses Global Positioning System (GPS) technology to optimize farming practices. This technology allows farmers to accurately locate and map field boundaries, as well as track the movement of agricultural equipment. By doing so, farmers can implement site-specific management practices, such as planting, fertilizing, and irrigating crops, that are tailored to the specific needs of each section of the field. (Shanwad, Patil, Dasog, Mansur, & Shashidhar, 2002)

As the global population is expected to increase by nearly 10 billion people by 2050, it is imperative to enhance agricultural productivity to meet the growing demand for food. Precision agriculture and advanced technologies such as automation, computer vision, artificial intelligence (AI), and machine learning are already revolutionizing the agricultural industry, and GPS technology plays a vital role in making this possible. (Wadhwa, 2022)

GPS technology in agriculture enables farmers to collect and analyze data about their fields, including soil moisture, nutrient levels, and plant health. This data can be used to create site-specific management plans, ensuring that crops receive the exact amount of water, nutrients, and other inputs needed to grow and thrive.

Remote Sensing

The use of remote sensing to measure crop health is becoming increasingly popular. By acting as early warning systems, sensors can help detect climatic or biological issues before they negatively affect crop yields. In the agriculture industry, remote sensing technology plays a vital role in evaluating plant health, estimating crop loss percentage, managing irrigation, identifying crop stress, detecting pests and weeds, forecasting the weather, and gathering information about crop growth stages. Combining remote sensing data with crop simulation models is a growing trend in predicting crop yields due to its potential benefits. (Adhikary, et al., 2022)

Using remote sensing technology reduces the need for collecting field data and improves the accuracy of estimates. It allows for the monitoring and quantification of crop stress caused by both biotic and abiotic factors. Other applications of remote sensing in agriculture include estimating acreage, mapping and monitoring drought conditions, maintaining vegetation health, assessing crop conditions in stress-prone environments, monitoring nutrient and moisture levels in fields, measuring crop evapotranspiration, using precision agriculture for weed management, and transferring atmospheric dynamic predictions through various satellites.

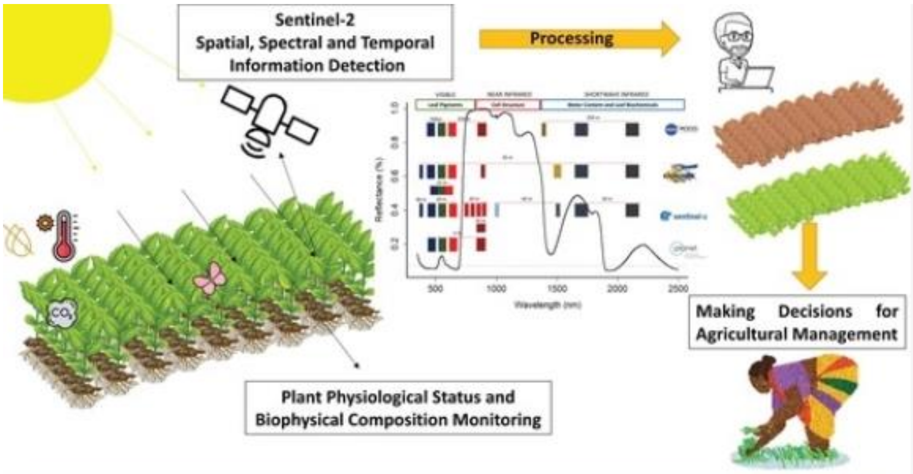

Figure 2. Remote sensing for agriculture monitoring (Segarra, Buchaillot, Araus, & Kefauver, 2020)

Robotics and Artificial Intelligence (AI)

Innovative technologies such as computer vision, artificial intelligence algorithms, and robotics are revolutionizing the agricultural sector. These technologies offer numerous advantages to crop and livestock farmers, allowing them to increase productivity while reducing their environmental impact. AI, in particular, enables precise observation and measurement of growers' requirements, making large-scale precision agriculture feasible.

Through the use of computer vision, AI algorithms, and robotics, farmers can collect more comprehensive, accurate, and timely data on vital parameters such as crop health and soil moisture levels. This data empowers farmers to make informed decisions on irrigation, fertilization, and pest control, ultimately boosting efficiency and profitability. Additionally, these technologies optimize labor allocation and reduce manual labor. (Pobla & Breton-Cailleaux, 2023)

One of the most significant advantages of AI in agriculture is its potential to minimize the environmental impact of farming practices. By reducing chemical use, improving water management, and optimizing soil health, AI promotes sustainability in agriculture. Integrating these advanced technologies into farming practices allows growers to tackle modern agriculture challenges while also promoting sustainability and profitability.

Application of the precision agriculture system in different climatic conditions

Although climate change is a natural process on our planet, its pace and magnitude have accelerated significantly in the last century. (Elijah, 2022) This has resulted in a range of challenges across various industries, particularly agriculture, which is heavily reliant on natural conditions. Changes in climate, such as reduced seasonal rainfall, have forced farmers to adapt their cultivation practices. (The

Role Of Climate Data In Precision Agriculture, 2021) However, the emergence of the Internet of Things (IoT) offers a potential solution, as it has facilitated the rapid advancement of Unmanned Aerial Vehicles (UAVs) and Wireless Sensor Networks (WSNs). These technological developments can be applied cost-effectively in Precision Agriculture (PA), including aerial crop monitoring and smart spraying tasks. The application of precision agriculture systems may vary depending on the climatic conditions of a specific region. (Radoglou-Grammatikis, Sarigiannidis, Lagkas, & Moscholios, 2020)

Application in dry climate areas

In dry climate areas, where water resources are scarce, precision agriculture can play a significant role in water conservation and sustainable farming practices. By using real-time data on soil moisture levels and weather patterns, farmers can apply water more efficiently, reducing waste and ensuring crops receive adequate hydration. This is achieved through precision irrigation, which delivers water directly to the plant roots, minimizing evaporation and runoff. Precision agriculture can help farmers identify areas where water is scarce and prioritize irrigation based on crop needs and water availability. (Tilman, Cassman, Matson, Naylor, & Polasky, 2022)

Another application of precision agriculture in dry climates is the use of remote sensing technologies, such as satellite imagery, to monitor crop health and detect stress factors, such as drought, salinity, or nutrient deficiency. By identifying these stress factors early on, farmers can take corrective actions to mitigate their impact on crop yields. (Zhang, Sun, & Deng, 2019) This can be achieved by adjusting irrigation and fertilization practices, or by selecting crops that are better suited to the local climate conditions. (Robin Gebbers, 2010)

Application in humid climate areas

In humid climate areas, where rainfall is abundant, precision agriculture can play a significant role in maximizing crop yields and promoting sustainable farming practices. One of the primary benefits of precision agriculture in humid climates is the ability to optimize fertilizer application. By taking into account soil characteristics, plant requirements, and environmental conditions, farmers can apply fertilizers more efficiently, maximizing nutrient uptake by crops and reducing the risk of nutrient leaching into groundwater. This can lead to improved crop yields and environmental sustainability.

Another application of precision agriculture in humid climates is its ability to reduce soil erosion and improve soil health. Precision agriculture can assist in water management by monitoring soil moisture levels, predicting rainfall and evapotranspiration rates, and optimizing irrigation scheduling. This can help farmers conserve water resources and minimize water waste, leading to improved environmental sustainability and cost savings. (Abdullah, Siraj, & Hodgett, 2021)

Application in cold climate areas

Cold climate regions are characterized by low temperatures, a short growing season, and limited water resources. One application of precision agriculture in cold climate areas is the use of sensors to monitor soil and air temperature, moisture levels, and other environmental factors in real time. By gathering data from these sensors, farmers can make informed decisions about planting, irrigation, and fertilization practices to optimize crop growth and improve resource use efficiency.

Precision agriculture can also help farmers in cold climate areas manage crop stress factors, such as cold temperatures and frost. Also, farmers can use remote sensing technologies, to prevent frost damage. Precision planting and tillage techniques can also reduce soil disturbance and improve soil structure, leading to reduced soil erosion and improved water infiltration.

Another application of precision agriculture in cold climate areas is the use of unmanned aerial vehicles (UAVs) to monitor crop health, detect disease outbreaks, and assess crop damage caused by natural disasters such as hailstorms. UAVs can capture high-resolution images of fields and use algorithms to detect and quantify crop health parameters, enabling farmers to take timely and targeted actions.

Application in warm climate areas

In warm climate areas, high temperatures and intense sunlight can pose challenges to crop production. (Hatfield & Walthall, 2015) One of the primary benefits of precision agriculture in warm climates is its ability to optimize irrigation. By leveraging data on soil moisture levels, weather conditions, and crop water requirements, farmers can apply irrigation more efficiently, and reduce water waste. This can be achieved by using precision irrigation systems, such as drip irrigation, that deliver water directly to the plant roots, reducing evaporation and water loss to the surrounding soil. Precision agriculture can help farmers conserve water resources and minimize water waste by monitoring soil moisture levels, predicting rainfall and evapotranspiration rates, and optimizing irrigation scheduling.

Conclusion

Precision agriculture systems have revolutionized the farming industry, and their application in different climatic conditions has been critical in ensuring optimal yields and resource management. The use of big data analytics, machine learning, and artificial intelligence in precision agriculture has enabled farmers to make data-driven decisions, leading to more efficient and sustainable farming practices.

The review of different systems of precision agriculture, including GIS, GPS, Remote Sensing, Robotics, and AI, has shown that each system has its advantages and disadvantages, and their success depends on the specific climatic conditions and crop cultivation practices.

In dry climate areas, precision agriculture has enabled farmers to conserve water resources by leveraging data on soil moisture levels and weather conditions to apply irrigation more efficiently. In cold climate areas, precision agriculture has helped farmers to optimize crop production by monitoring soil temperature and implementing measures to protect crops from frost damage. In warm climate areas, precision agriculture has enabled farmers to monitor crop health and detect stress factors, such as drought, salinity, or nutrient deficiency, to take corrective actions to mitigate their impact on crop yields.

Precision agriculture has played a critical role in improving agricultural productivity, sustainability, and resource management. As the world's population continues to grow, the need for more efficient and sustainable farming practices will only increase, and precision agriculture systems will continue to evolve to meet these challenges.

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GASTRONOMY AS A FACTOR OF RURAL DEVELOPMENT - THE EXAMPLE OF VOJVODINA FARMS

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Abstract

Tradition and gastronomy are synonyms that point us to lasting values and quality. People travel from faraway places to enjoy authentic food, characteristic of a certain area. In this way, many dishes are kept from being forgotten, and enjoying them is a form of sustainable tourism.
The paper started from the hypothesis that gastronomic tourism has the potential to be the carrier of the economic development of rural areas. Tourists want an authentic experience through food. In this way, tradition is preserved from oblivion, and rural areas revive and develop.
There were questioned 218 tourists, visitors to 10 farms in Vojvodina as authentic objects of rural areas. The conclusion was reached that the rich gastronomy is a factor in attracting tourists that has a strong contractive effect, whether it is a primary, independent tourist motive or a complementary tourist offer.

Key words: Gastronomy, rural tourism, sustainable tourism, farms of Vojvodina.

Introduction

Sustainable tourism implies an economic branch that has a minimal impact on the environment and local culture, while helping to generate income, new jobs and protect local ecosystems (Cong, 2016). It is a responsible tourism which is friendly towards natural and cultural heritage. Although there is no universal definition of sustainable tourism, the majority of researchers agree that sustainable tourism means "any type of tourism that contributes to the protection of the environment, social and economic integrity and improving natural, created and cultural values on a permanent basis" (du Rand and Heath, 2006). The main goal of this type of tourism is duration, and the synonym of duration is quality (Baker, 2000, Mihailović, 2004). Working and acting in such a way that everything we turn into a "product" is a pledge of the future.

One of the most obvious examples of sustainable tourism is certainly rural tourism. Rural tourism is often considered an essentially sustainable form of tourism (Ekinci et al., 2013). It is the tourism of the rural area with all the activities that are carried out in that area. Nature is the basic resource for the development of rural tourism. Rural tourism should contribute to the preservation of the rural environment and cultural heritage, but also economically motivate the local population to stay there, creating conditions for a comfortable life (Vujko et al., 2016). This type of tourism could greatly contribute to the protection of nature, i.e. autochthonous species of flora and fauna, but also provide funds for development and investment in the village. The greatest value of a holiday in the villages is untouched nature, clean air, clean water, healthy food and the traditional hospitality of our hosts (Ignatov and Smith, 2006). A large number of villages are located near valuable cultural and historical monuments that tourists can visit in an organized manner. The buildings of traditional architecture with the characteristics of the area, as well as the products of old crafts and handicrafts, through which the rich heritage of the people can best be known, also have exceptional cultural value (Petrović et al., 2017).

Staying in villages offers tourists the opportunity for walks, recreation, playing sports, organized tours of nearby natural and anthropogenic monuments, as well as various exhibitions and art colonies that are organized in the environment, with the possibility of practice of hunting and fishing (Nield et al., 2000). Vojvodina is one of the largest and for agriculture the most suitable areas in Serbia. At the same time, this is an area which is inhabited by a large number of nationalities. Each of them, with its culture and tradition, contributed to the formation of an interesting image of this area (Todorović and Bijeljac, 2007).

One of the most impressive tourist attractions of rural tourism, which is sustainable and attractive at the same time, is gastronomy (Boyneet al., 2003). In recent times, it stands out as an independent tourist attraction within gastronomic tourism (Lawrence et al., 2012). Gastronomic tourism is defined as the visit of tourists to primary or secondary food producers, food festivals, catering facilities for food production and serving, and certain destinations for tasting and experiencing regional specialties, where food is the primary motive for travel (Wolf, 2006). Some authors believe that this definition is more than sufficient to explain all aspects of gastronomic tourism.

Wine, food and tourism are closely related. However, just recently has the wine and food role played by in attracting tourists to a destination been explicitly recognized by governments, researchers and the wine, food and tourism industry (Everett and Aitchison, 2008). Food has become recognized as a part of local culture in the tourist market; part of tourist promotion; potential component of local agricultural and economic development; a regional factor influenced by consumption patterns and the observed desires of tourists (Cohen and Avieli, 2004; Olsen, 2007).

The paper started from the hypothesis that gastronomic tourism has the potential to be the carrier of the economic development of rural areas, that is, that gastronomic tourism increasingly attracts tourists on its own. Food becomes an independent tourist attraction, to which he is always happy to return.

Farms (named Salaši) and gastronomic offer of Vojvodina

Gastronomy of Vojvodina was formed as a reflection of complex living conditions, geographical characteristics, natural conditions and social events in this area. In the area of Vojvodina, there is a large mixture of cuisines, and therefore a large number of different dishes (Zečević et al., 2021). This cuisine is a mixture of different influences of the peoples who have lived in this area for centuries. The arrival of the Germans greatly influenced nutrition and food preparation in Vojvodina. They brought their own dishes, customs, preparing winter food, wine, growing fruit and vines, so the Serbian population adopted a lot of their dishes and ways of preparing food. Also, in Vojvodina there is a wealth of culinary knowledge and the mutual influence of Hungarian, Romanian or Slovak cuisine, and numerous dishes are derived from Russian or some other cuisine from the surrounding area (Kalenjuk et al., 2011).

Various influences make Vojvodina cuisine specific and therefore attractive for tourist demand, especially since the diet of the population has changed the least compared to other forms of changes in the cultural life of the village.

The influence can also be seen in the names of many dishes preserved to this day: from the German frustuk/breakfast (Das Früstück), breakfast/snack (Die Jause), appetizer/appetizer (Die Vorspiese), rindfleisch/beef (Die Rindfleisch), cushpaize/stew (Die Zuspeise), dumplings, strudels, donuts... from Hungarian: perklet/fried meat in its own sauce (Pörkölt), goulash (Gulyás), paprikás (paprikás) and others (Gavrić, 1994).

Since ancient times, food was prepared in the house by the oldest women freed from the main agricultural work, and the rest of the household was in the field. Freshly baked bun or bread, smeared with lard and sprinkled with ground red pepper, was often eaten. During the winter in Vojvodina, there were three meals from ancient times: breakfast or fruštuk (at 7 a.m.), lunch (always at noon) and dinner at (6 p.m.). During the summer, when the days were longer, there were more meals. In addition to the usual ones, in the morning around 10 o'clock there was a yauzna or small uja, and in the afternoon around 5 p.m. there was a big uja. For these meals, apples in a dressing gown, bread and fat with ground red pepper, etc. were usually prepared. Those who found themselves in the field often only knew to eat some seasonal fruit and bread.

In terms of gastronomy, Vojvodina belongs to heavenly enjoyment place. Delicacies, which are hard to resist, set the stamp on Vojvodina cuisine, praised for its challenging tastes, smells and colors. In Vojvodina cuisine, "fruits of the barn" rule, and there are almost no dishes without meat and dried meat products (Gavrić, 1994).

In Vojvodina, it is customary to always have something to snack on between the five mandatory meals: breakfast, two snacks, lunch and dinner. Fruštuk, or breakfast, was the most abundant daily meal that provided the energy base for a hard-working day. Bacon, ham, cracklings, sausages, kulen, but also cold meats, cheese, cream, scrambled eggs, pies and a lot of bread were eaten. The sweet part of breakfast included bread and jam, compote, pancakes, donuts, etc.

Yauzna (snacks) bridged hunger from breakfast to lunch, that is, from lunch to dinner. The morning included bread spread with pâté, lard, jam, the bread sprinkled with water and sugar (so that the sugar sticks better), scones, rolls, apple and everything that is eaten on the go, without cutlery. For the afternoon snack, soft pastries, fruit cake, and pudding were eaten (Kalenjuk et al., 2011).

The most characteristic meal in Vojvodina is lunch, yet. It can be the daily lunch, which consists of soup, dough and potatoes, but it can be festive and imperial, and the most famous is Sunday lunch. It consists of: beef soup with noodles, rinfleish with tomato sauce, roast pork with potatoes and the obligatory sausage, various salads and desserts: šrudle, small cakes, schne nokle...

Dinner in Vojvodina houses never existed just for the sake of order. There were always cooked dishes, fried meat, dried meat products.

Soups are an indispensable part of every Christmas and Sunday lunch, but they are in front of the household on other days as well. They are cooked from beef, chicken, turkey, goose, duck, pork and pigeon meat. Soups are made from various ingredients, but also only from herbal spices and tarana.

Broths are part of the tradition of Vojvodina cuisine. The most famous are ragu stews made from vegetables, beef, chicken and lamb, and also fish stews. Special nostalgia evoke ajnpren, tomato and wedge - stews. On the table in Vojvodina, pork, poultry, beef and lamb are mostly represented. From this meat are made popular "Wiener", "Paris" and "natur" schnitzels, filled with cream, cheese, chopped ham and bacon. Until half a century ago, pork, lamb, veal and kid were never prepared in “paorian” houses, because it was a sin to slaughter a lamb, pig or calf. Today, young meats are an integral part of the menu, especially on festive occasions.

Paprikashi, vegeti, goulash and tokanji resist the onslaught of new dishes and are specialties that are appreciated. Freshwater fish (carp, perch, catfish, pike, walleye, bream, bream, tench) is an essential part of the Vojvodina diet, whether they are in soup or parikaš, baked in the oven, on the grill, or on the “talandera”. Stew and goulash are prepared from wild game, which, in combination with forest fruits, vegetables and berries, make up the exclusive gastronomic offer of Vojvodina. Nevertheless, for the people of Vojvodina are favorite dishes that are eaten with a spoon: đuvec, beans, sarma, stuffed peppers and stews cooked thickly, such as a side dish to meat, and they are made from peas, green beans, cabbage, kale, zucchini and, of course, with the inevitable potato, prepared in all possible ways. All of this is accompanied by appropriate salads of tomatoes, peppers, cabbage (sweet and sour), cucumber, beets, pickles, as well as Serbian and Chopin salads, as well as compote salads. Dough is also part of the tradition of Vojvodina cuisine. Most often, they are rolls and scones, plain, salty or sweet, and the best ones are those with cracklings; dry, specific Vojvodina dishes made from dough with noodles; valjušci, trgančići, tarana, shufnoodle; gibanica, usually with cheese, but also with cherries, apples, semolina, poppy seeds, pumpkin, walnuts and the like.

Vojvodina delicacies got their name not only because they are sweet, but also because they are eaten for pleasure.). Cakes of various colors, shapes, and all of them sweet (wafers, krancles, gurabies), strudels with poppy seeds, walnuts, cherries, carobs or raisins are one of the most recognizable symbols of Vojvodina. The people of Vojvodina also love taške, dumplings, doughnuts, pumpkin and pancakes, either with apricot and rosehip jam or cheese, but most of all, šne nokle or bird milk, a delicacy that somehow best spices up the end of a meal. The Vojvodina kitchen is full of the smell of gardens, pantries, sideboards, the taste of sweet fruit preserved in jars, and bottles filled with everything - from boiled tomatoes to elder juice. It is the plain of fertile chernozem and spacious pastures, river valleys, canals and fishponds net, numerous of hunting grounds, orchards and vineyards on Fruška Gora and the Vršačke Mountains, the sandy plains around Subotica.

The aim of this study was to find out from 218 respondents what they think about the importance of gastronomy and its potential and how gastronomy, as a tourist attraction, attracts tourists to come and enjoy food.

Methodology

The research was carried out in 10 Vojvodina farms, characterized by the fact that they have been transformed into a kind of authentic gastronomic mecca. There are 218 respondents, visitors to the farm, who came there to enjoy specific and unique gourmet cuisine. The respondents were asked a group of questions about the importance of gastronomy and its potential. We also wanted to get an opinion in what way gastronomy, as a tourist attraction, attracts tourists to come and enjoy food. The research was part of a wider research project, and the paper presents responses grouped by similarity. A survey containing 16 questions was used, and the research lasted from March to June 2023.

The Chi-square test (Pearson Chi-Square Test) was used as the method of analysis. The test showed statistical differences in respondents' answers in relation to gender, as the most common type of comparison in respondents' answers. The assumption was that there was no difference in the answers. Statistically significant differences are taken for those having $p < 0.05$.

Results and Discussion

Looking at table 1, it can be seen that 107 male and 111 female respondents participated in the research.

Table 1. Gender

		Frequency	Percent
Valid	Male	107	49,1
	Female	111	50,9
	Total	218	100,0

Table 2 shows the reasons for coming to farms. And it is this group of answers that confirms the initial hypothesis. The respondents agree that the food on the farms is unique, traditional, tasty, and homemade. Table 3 shows that there is no statistically significant difference in the responses of respondents in relation to gender.

Vojvodina is a large granary, and therefore people in Vojvodina know how to make good and quality dishes from dough. The culture of making bread and dough dishes in Vojvodina developed under the influence of several traditional cuisines: Serbian, Austrian, Hungarian and Turkish. That is why Vojvodina cuisine is characterized by great variety in the preparation of all kinds of breads and cakes from bread dough.

Most of the farms attach great importance to the quality of the preparation of the bread and pastries that they bring to the guests. However, on farms and ethnic houses that promote local traditional specialties, in order to complete the experience, bread, pastries, pasta and other bakery products are produced in the household itself, in order to maintain the tradition. Farm housewives get up at dawn to provide their household and guests with fresh bread every day. White bread is most often produced, followed by semi-white and black bread, Vojvodina bread with added milk. In addition to bread, they also produce scones, buns, soft cakes, fritter, scones with crackling, various pies and “gibnica” - pie from hand-rolled crusts with cheese and various greens, polenta, “proja” (corn bread), “cicvara”.

Table 2. Reasons for coming to farms

		Gender		Total
		Male	Female	
The reason for coming to the salaš farm?	Extraordinary food	3	14	17
	Food reminds me of my childhood	9	17	26
	Tradition and culture	17	13	30
	Food that is healthy	20	11	31
	A specific taste that cannot be felt anywhere else	26	10	36
	I love the relationship the hosts have with the guests. I feel at home	9	19	28
	I like to eat food that has "soul"	13	14	27
	Food and wine are pure hedonism	10	13	23
Total		107	111	218

Table 3. Pearson Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	23,771[a]	7	,001

As for desserts, there are strudels with poppy seeds, walnuts and cherries, pumpkin pie, cherry pie, apple pie, dumplings, noodles with poppy seeds, salčić. And as an addition to the main dishes such as goulash, stew, perkelt, homemade noodles are served. It is often served dry with potatoes, "flecks" (pasta) with cabbage, noodles with cheese. Each household has its own recipe for the production of these products and each housewife has her own secret that is passed down from generation to generation.

ZEKIN SALAŠ - Krčedin On offer: Prebranac, Tongue in brine, Pepper patties, Bread and lard, Goose pate, Cvarci, Pichte and the like.

There are products that are common to all farms, and that stand out from the offer as typically Vojvodina specialties. “Cipovka" is a product that is characteristic of this area. It is white wheat bread with yeast that goes perfectly with all national and international dishes. As pasta is used a lot on Vojvodina farms, it should be emphasized that there are a large number of domestic specialties made from cooked pasta, such as noodles with poppy seeds, breadcrumbs, cheese, dry noodles with potatoes, “valjušak” (dumpling), “flekica” (squear macaroni) with various additives that are used as a garnish for stews and perkelte, or as liners for soups. And at the end of every meal, dessert is indispensable. Although the offer is varied, the most commonly offered is strudel with poppy seeds, a traditional product that has a geographical indication of origin.

Table 4. Display of farms which fulfilled a wide range of requirements for successfully fulfilling the wishes of the modern guest

Salaš (farm)	Offer
DIDA HORNJAKOV" SALAŠ – Sombor	Yellow carrot soup with pasta flecks and liver dumplings, meat from the soup, rice with stewed gizzards is inevitable. Three types of sauce go with all of this: cherry, tomato and dill sauce. As here "everything is eaten in order", guests are then served gibanica with poppy seeds, walnuts, cherries, and pumpkin.
CVEJA'S SALAŠ – Begeč	We offer simple, folk dishes: sweet cabbage (Futo or Begeč) with turkey, and in another variant with kid, with a small addition of beef. Followed by greens salad (chard, horseradish leaves or vine leaves), "podvarak" podvarak, a (dish made from sauerkraut), beans with dry ribs and smoked pork leg. Salads are seasonal. Of course, homemade chicken stew, beef goulash, and pork delicias are excellent.
HOUSEHOLD "LEKIN SALAŠ" – Salaš Noćajski	We offer fish dishes: stews, paprikash, fried and baked fish and the like.
JELEN SALAŠ – Palić	Salaš house, built on sandy terrain, offers famous wines which vine was grown on the sand collected from the best cellars in the region. Salaš also offers typical Hungarian and Vojvodina dishes, but it is widely known for its Bosnian cuisine specialties.
MOTHER'S SALAŠ – Palić	"Kočijaška" schnitzel, Salš's "mućkalica", "Baćina" schnitzel, "Biroška" longing, Gypsy skewer, Turkey with apricots, Turkey with grinders, Pork cutlet in apple sauce, Ćevapčići, Burger, Smoked "hanger", White "hanger: Homemade sausage, Schnitzel in ajvar sauce, Chicken white meat, Filleted chicken, tripes
PERKO'S SALAŠ – Neradin	The menu usually includes chicken or beef stew with homemade mixed noodles, tomato soup with zucchini, soup, strudel with poppy seeds or walnuts, homemade brandy, wine and natural juices. The offer of sweets includes old-fashioned cakes and sweet pies, as well as plum, dogwood or pomegranate jam, watermelon, blackberry, wild strawberry jam. Instead of industrial liqueurs, cherry brandy and nut brandy are poured.
SALAŠ "KATAI" – Mali Iđoš	We offer dishes of local Vojvodina cuisine, with an emphasis on dough dishes and various types of homemade bread.
SALAŠ 137 – Čenej	The restaurant serves traditional Vojvodina cuisine (gibanica, imperial pie, strudel with

	poppy seeds and walnuts, pumpkin, rinflash with 5 sauces, rolled veal, fish on cream, Salaš sauté, stuffed zucchini).
WINE SALAŠ “ČUVARDIĆ” – Kelebija	Guests have the opportunity to enjoy dishes prepared according to old, home-made recipes, so the menu includes home-made scones with cracklings, potatoes in their husks, kneepads and various roasts, as well as stews cooked in a kettle. Food is prepared on a wood-burning stove, and when the weather is nice, the table is set up in the garden
ZEKA’S SALAŠ – Krčedin	On offer: Prebranac, Tongue in brine, Pepper patties, Bread and lard, Goose pate, cracklings, aspic and the like.

Source: Author's research

In Vojvodina, paori (peasants) prepared white wheat bread with yeast. The characteristic of Paor bread or cipovka is an extremely pleasant smell and taste, easy digestibility and durability for several days. Fresh bread was never eaten until the previous bread had been eaten. The special quality of dough pieces baked in this way was obtained primarily due to the indirect bread production process, a direct firebox with cornstalks and straw, and with delicious thick crust of bread that retained a sufficient amount of moisture so that the bread could be used for several days. The characteristic shape of the cipovka comes from the cutting of the round piece of dough (at the top of the dough ball) and from the moisture gradient that is created after putting the dough into a heated oven (“furuna”).

The appearance of strudel with poppy seeds and walnuts is linked to an anonymous confectioner from Požun from the 16th century (Požun or today's Bratislava), who made small horse-shoe-shaped rolls from poppy seeds for Saint Nicholas and distributed them to children. Under the influence of Austria-Hungary during the second half of the 19th century, Christmas strudel with poppy seeds is prepared in these areas. Vojvodina strudel with poppy seeds and walnuts was created with the help of Vojvodina housewives, who introduced innovations in the preparation of this delicacy, adapting it to the local taste. Viennese and Vojvodina strudel with poppy seeds differed in the thickness of the crust. The Viennese one had a thicker crust, while the Vojvodina one had a thinner crust. The Vojvodina strudel with poppy seeds is made from flour originating from domestic, Vojvodina wheat varieties. Popović et al., (2020a) and Glamočlija et al., (2015) highlight the quality of domestic wheat varieties, which are grown in accordance with varietal technology, adapted for these areas with characteristic agroecological and soil conditions.

Vojvodina strudel with poppy seeds is a traditional product from the Vojvodina region and is produced exclusively by hand. This product is one of the few that is offered by every farm.

Pasta made from wheat flour with the addition of water forms the basic dough for these products. In some places, eggs or blended vegetables are added to this mixture to give the pasta color. It is cut in the form of narrow, straight straight strips of different widths and lengths, or they are bent or twisted into various shapes. In addition to the above, they can be produced in households in the form of tarana and flakes, and in industrial production these forms can be very diverse. They are cooked in plenty of hot boiling water. They can be served as a main dish (with butter, cheese, various sauces, poppy seeds, breadcrumbs) or as a side dish with various types of meat. They are also used as inserts for various soups and stews.

On farms, noodles are most often prepared (rolled dough with cheese, semolina, poppy seeds and milk), “valjuški” (boiled dough with fried semolina), and “tašti” with jam (the dough is rolled out like a pie and jam is placed, as small heapses, on one half at a distance of a few centimeters, then is folded over with the other half of the dough, then cut, the edges of the dough are joined so that the jam does not leak, it is cooked in boiling water, then it is rolled or sprinkled with fried breadcrumbs and eaten that way). The range of pasta products is very diverse. In addition to the traditional pasta dishes they prepare, today's chefs modernize them and adapt them to the tastes of increasingly demanding tourists.

Pogača is usually round, but it can be more or less oval or flat bread, Figure 1a. The taste and aroma of this bread can be different, depending on the additions and spices. Erstwhile, pogače were kneaded for special cases, and most of them were related to some ritual actions. It is usually kneaded when someone is going on a long journey, or it is worn by workers in the fields, to women that just given a birth to welcome guests, and it was necessarily prepared for funerals and funeral feasts, for baptisms and Christmas. On the farms, two types are usually made, with milk and with water, but every housewife knows how to surprise her household and guests with a sumptuous pogača to which various spices and accessories have been added.

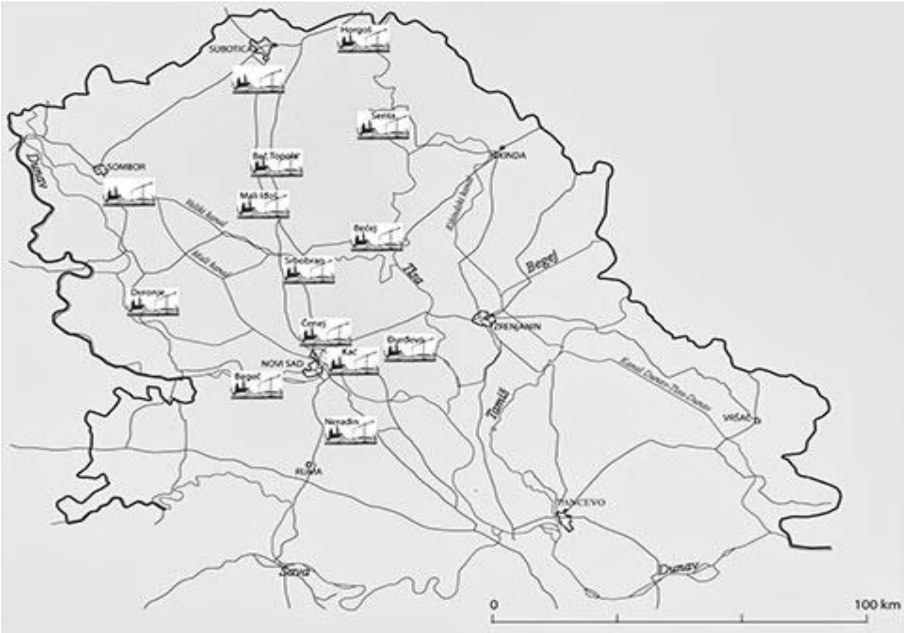

Figure 1. Thematic map of the most important farms in Vojvodina (www.vojvodinaonline.com)

Buns are smaller and thinner loaves of round or elongated shape prepared from wheat flour with the addition of yeast, a little salt and sugar, Figure 1b. Sometimes it is made without yeast. Before baking, it is usually sprinkled with cumin or sesame seeds. It is baked on a heated plate for about 20 minutes. It can be served warm with cream and cheese, but traditionally it is served warm with lard and ale or crushed pepper, or cold as a substitute for bread.

Gibanica is a traditional mixture of local cheese, cream, eggs, fat or oil, baked in gibanica crusts, Figure 1c.. There are various varieties, but cheese is always the basis for all gibanica, it is even preferable that the cheese be full-fat and fermented. The crusts can be developed in two ways: with a rolling pin on a board or by hand on tables covered with tablecloths and in a much faster way, which requires a skilled housewife who has a feel in her hands so crusts do not crack. This way of developing the crust requires well-aged wheat flour. Sieve the flour on a board, then make a well and add oil and cold water as much as is needed to knead the dough. The dough must be kneaded until it begins to separate from the hands. The housewife will separate the noodles from the mixed dough, roll out them a little, coat them with oil and cover them with a clean cloth to rest. The dough needs to rest well so that the stretching can take place as well as possible. When the dough has rested enough, on spread tablecloth on the table, roll out one noodle at a time. First, the noodle is stretched in the air with clenched fists. Then it is placed on the table and stretched in a circle with both hands. When the bark is spread ends should be tear off. Housewives can roll out those leftovers with a rolling pin later when they have stretched all the skins. The stretched crusts are then filled by sprinkling the filling on them, and then the crusts are rolled up with a tablecloth and placed in a pan.



a) b) c)

Picture 1. Vojvodina’s pogača (a), bun (b) and gibanica (c)

The filling for gibanica can be very diverse. Cheese is almost always used as a base in salty gibanica, various greens can be added to it: Swiss chard, spinach, nettle; although you can also make gibanica from potatoes, cabbage or leeks, and it's all a matter of the imagination and skill of the housewife. However, the most common gibanica on the farms in Bač is gibanica with cheese and green vegetables. The other names come from the name of the food used to fill gibanica, so we have: bundevara (pumpkin), krompriusha (potato), kopusara (cabbage) and others.

One of the most common delicacies made from stretched crusts is pumpkin. The filling is prepared by grating the pumpkin and putting it on the stretched crust, and then it is sprinkled with a mixture of sugar and cinnamon or vanilla sugar and then rolled up. Pie with cherries is also made in the same way. Cherries are arranged on the crust, sugared and with semolina, and then twisted. Although these pies and gibanica are much tastier when they are prepared with homemade crusts, today's housewives often use store-bought crusts due to lack of time, which greatly speeds up the process of making these specialties.

A tourist product is, as businessmen usually call it, "a collection of a large number of small things". It is one compositional product or a mixture of various elements that contains segments of attractiveness, transportation, accommodation and environment (Okumus et al., 2007). The tourist product, in essence, represents "a collection of various benefits, goods and services that serve to satisfy the tourist needs of the customer during his trip and stay on the farms of Vojvodina. It should be also borne in mind that good offer represents not only modernly equipped rooms, friendly service and good cuisine, but also a parking spaces, because a large number of tourists come by car.

Tourism can be beneficial for farms in many ways as a protected natural asset, and a few observations stand out. The true is that tourism development is predestined in destinations with relatively well-preserved nature, such as in protected natural assets - farms and that fact helps modern man to imagine what nature and life looked like before industrialization and man’s destructive action, in general.

Conclusion

Only those companies (farms) that offer a wide range of content can expect success. This is the only way to satisfy the choosy demands of tourists. It is necessary to provide a very diverse and rich offer in the direction of creating an integral product, that is, a package-arrangement. This implies a very synchronized activity of companies (farms), agencies, local tourist organizations and local communities.

Tourism is an important factor in the protection of natural resources. The problem of nature protection can also be viewed from the perspective of tourism development.

When we mention tourism as a factor of importance for objects of protected nature, then we primarily think of tourism as an economic category, which can finance nature protection from the collection of tourist services.

Tourism helps to detach the village socially and culturally from provincialism and to support the economy of local communities; Finally, there is an educational component that makes protected nature facilities support the environmental education of children and adults.

Due to the slow economic and industrial development, the last decade contributed to a lower concentration of the harmful agent that pollutes the environment (land, water, air) compared to the developed countries of the European Union. That is why food produced in these areas is healthier. In addition, the production of vegetable and animal raw materials is characterized by a smaller share of chemical elements (additives, hormones, artificial colors, flavors, etc.), which directly contributes to the quality of the gastronomic offer of the Vojvodina plain, which represents its competitive advantage.

The future of the gastronomic product as part of the tourist offer of Vojvodina must include, in addition to the mentioned ecological parameters, a long-term marketing plan that would guarantee the creation of a positive image necessary for presentation on the world market.

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ECONOMIC EMPOWERMENT OF WOMEN IN RURAL AREAS OF VOJVODINA THROUGH PARTICIPATION IN TOURIST ACTIVITIES

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Abstract

The subject of research is the economic position of rural women in Vojvodina, as well as their role and importance in the development of rural tourism. The aim of the work is to investigate the current position of women on the labor market in rural areas of Vojvodina and the possibilities for their economic empowerment and change in the quality of their lives through participation in tourist activities. The methodology of the work is based on the application of the inductive-deductive method, methods of analysis and synthesis, and the comparative method. Although dominant, the female rural population of Vojvodina has a less favorable economic position compared to the male population. The development of tourism in rural areas could contribute to the economic empowerment of women with correspondingly more intensive development of this activity and greater state support for this category of the population.

Key words: Rural tourism, rural women, economic empowerment, rural development, Vojvodina.

Introduction

Rural areas of Serbia, depending on the applied criteria of rurality, occupy 70-85% of the territory of Serbia and 43-55% of the total population lives in them.

In the economic structure of rural areas, agricultural activity has a significant share and a high rate of population employment in this sector is recorded. The high degree of dependence of the rural population on agricultural activity is also an indicator of the low degree of diversification of economic activities in rural areas, which significantly limits employment opportunities. The problem of unemployment, unfavorable age and educational structures are more pronounced in rural than in urban areas, and therefore poverty in those areas. Farmers who depend exclusively on income from agriculture, the elderly and pensioners, young people, displaced persons and women are particularly vulnerable categories of the rural population.

The variety of preserved natural and cultural resources of rural areas is a rich basis for numerous development opportunities, some of which are underutilized or not used at all. The development of tourism in rural areas could contribute to their economic and socio-cultural revitalization and the economic empowerment of vulnerable categories of the population, including women.

Rural areas of Serbia are a source of human resources needed for the development of rural tourism. Among the available human resources for work in tourism, the female population is particularly important. Despite the numerous advantages of engaging the female labor force, in rural areas among the vulnerable groups of the population are, in addition to the poor, young people and women who are affected by unemployment (Milošević et al., 2012).

Research on the position of women in rural tourism indicates the unfavorable economic position of women. Gender inequality, which to some extent is still present in Serbia, is more pronounced in rural areas. In rare cases, a woman is the owner of an agricultural farm, even if the jobs in a certain household are equally distributed (Ćosić, 2019).

Compared to men in the countryside, there is a higher participation of inactive and unemployed among rural women (55% of women compared to 39% of men) (Gajić and Vukolić 2021). The same research reveals a very weak connection between the female labor force and rural tourism, although they can contribute to the improvement of the development of this tourist activity. The results of recent research confirm that women's work is not just a supplementary activity, but plays a key role in maintaining rural tourism on the observed farms and has a leading role (Duarte et al., 2018).

The subject of research is the economic position of rural women in Vojvodina, as well as their role and importance in the development of rural tourism. The aim of the paper is to investigate the current position of women on the labor market in rural areas of Vojvodina and the possibilities for their economic empowerment through participation in tourist activities.

Material and method of work

In the work, the research methodology is based on the application of the inductive-deductive method, the methods of analysis and synthesis, and the comparative method. As a source of data, the publications of the Statistical Office of the Republic of Serbia, as well as other relevant organizations, as well as the results of some earlier but also the most recent researches in this field are used as a source of data.

Results with discussion

Rural areas

According to the data of the Republic Statistical Yearbook from 2022, the population of the Republic of Serbia lives in 197 municipalities, 45 of which are located in the territory of Vojvodina. On the territory of Vojvodina, there are 467 populated places distributed in 45 municipalities and 7 districts: Severnobačka, Srednjebanatski, Severnobanatski, Južnobanatski, Zapadnobačka, Južnobačka and Sremski. Out of a total of 29 cities, 8 are in the territory of Vojvodina. The total number of inhabited places in the Republic of Serbia is 6,158, of which 467 are in the Vojvodina region.

During the population census, the Republic Statistical Office of Serbia classifies all settlements into "urban" and "other", which include mainly rural and suburban settlements.

Table 1. Inhabited places on the territory of Serbia and Vojvodina (January 1, 2022)

Type of settlement	Republic of Serbia	%	Vojvodina	%
Urban settlements	193	3,1	52	11,1
"Other" (rural) settlements	5.965	96,9	415	88,9
Populated places:	6.158	100	467	100

Source: Statistical yearbook of the Republic of Serbia, 2022

Out of 193 urban settlements, 52 are in the Vojvodina region. It can be seen that the entire area of Serbia is dominated by "other" settlements, whose share is around 97%, which indicates that Serbia is predominantly rural. Urban settlements make up only about 3%. The share of "other" settlements in Vojvodina is about 89%, and urban settlements record a share of only about 11%, data that also indicate the predominantly rural character of the Vojvodina region.

Residents of rural settlements in Vojvodina are those persons who reside in a populated place where the seat of the city is not located. On the territory of Vojvodina, eight units of local self-government have the status of a city: Novi Sad, Subotica, Zrenjanin, Pančevo, Vršac, Sremska Mitrovica, Kikinda and Sombor - Law on Territorial Organization of the RS, ("Službeni Glasnik RS", no. 129/2007, 18/ 2016 and 47/2018).

The average population density in the Republic of Serbia, according to the Census data from 2011, was 92.6 inhabitants per 1 km² of area. The Belgrade region stood out as the most densely populated region with an average population density of 513 inhabitants per 1 km² of surface area, while the regions of Southern and Eastern Serbia with 60 inhabitants per 1 km² of surface area are the least populated regions.

Also, the network of settlements in Vojvodina is not characterized by high population density. The average population density in Vojvodina is 89.4 inhabitants per square kilometer, which is less compared to the national average, as well as compared to the previous census from 2002, when an average population density of 94 inhabitants was recorded. According to the 2002 Census, a total of 2,031,992 inhabitants lived in the region of Vojvodina, which covers an area of 21,614 km², and in 2011, that number was 1,931,809.

According to the 2011 Census, 7,186,862 inhabitants lived in the territory of the Republic of Serbia, of which 1,931,809 were in the Vojvodina region. The urban population of Serbia is 55.49% of the population, i.e. 3,965,884 inhabitants, while the rural population is 44.51% of the population, i.e. about 44.51%. In the area of Vojvodina, 55.38% of the population (i.e. 1,097,332) are in urban areas, and 884,084 that is, 44.62% are rural population (Cvijanović and Gajić, 2020).

There are numerous social and economic differences between urban and rural areas. They are particularly visible if viewed from the perspective of household income and consumption. The monthly average of income and personal consumption per household member in Vojvodina differs depending on whether households live in urban or "other" areas (rural).

Table 2. Monthly average of income and personal consumption per household member in Vojvodina, metropolitan area and other areas (2021)

Area	Average number of members	Income (RSD)			Personal consumption (RSD)
		In cash	In nature	In total	
Urban	2,42	28.816	232	29.048	29.572
„Other“	2,60	23.963	1.234	25.197	25.406

Source: Statistical yearbook of the Republic of Serbia, 2022

From the previous table (Table 2), it can be seen that households in urban areas have higher total incomes, with the largest part of the difference being related to the incomes in money. In the structure of income in money, the largest share is achieved by income from regular employment (53.4%), pensions (34.1%) and income from agriculture, hunting and fishing (2.8%). On the other hand, they receive less income in kind compared to households from the "other" area.

Households from the "other" area derive the largest part of their cash income from income from regular employment (43.0%), pensions (29.0%) and income from agriculture, hunting and fishing (10.4%). This income structure can be explained by the unfavorable age structure of the rural population and the fact that a significant part of the rural population in Vojvodina is engaged in agriculture.

It is also visible that the monthly average of personal consumption per household member from the "other" (rural) area is lower compared to the average of households from the urban area. Given the low incomes, high dependence of the population on agriculture and limited opportunities for employment, rural households have a need for additional sources of income, among which tourism appears as one of the possibilities.

Demographic characteristics of the female population in rural areas of Vojvodina

The female population dominates the territory of Serbia, whose relative participation in the total population is 51.3% (3,687,686), while males participate with 48.7% (3,499,176). In the area of Vojvodina, the dominance of the female population is also observed with a participation of 51.3% (992,192) over the male population, which records a participation of 48.6% (939,617).

According to the estimates of the Republic Institute of Statistics, in 2021 the total population was 6,834,326 inhabitants, of which 3,327,001 were men and 3,507,325 were women (which is a share of 51.3%). The Institute's projections are that in 2030 the total population will be 6,823,942, of which 3,312,001 will be men and 3,511,941 women (51.5%).

In 2040, according to the same projections, there will be a total of 6,816,430 inhabitants, of which 3,308,170 men and 3,508,260 women (51.5%). Apart from the constant trend of decreasing the number of inhabitants, which is explained by the negative natural increase and the departure of citizens abroad, it can be noted that the numerical superiority of the female population will remain in the future.

The average age of the population of Serbia in 2011 was 42.2 years, and a decade later, in 2021, it would be 43.5 years, which can be considered a very unfavorable trend.

Table 3. Average age of the population of the Republic of Serbia (2011-2021)

Year	Average age	Male	Gender female
2011	42,1	40,7	43,4
2012	42,2	40,9	43,6
2013	42,4	41,0	43,7
2014	42,6	41,2	43,9
2015	42,7	41,3	44,1
2016	42,9	41,5	44,2
Year	Average age	Male population	Female population
2017	43,0	41,6	44,4
2018	43,2	41,7	44,5
2019	43,3	41,9	44,7
2020	43,4	42,0	44,8
2021	43,5	42,0	44,9

Source: Statistical yearbook of the Republic of Serbia, 2022

The female population has a higher average age than the male population. Thus, for example, the average age of the male population in 2011 was 40.7 years (which is lower than the national average), and that of the female population was 43.4 years (which is higher than the national average). The average age of the inhabitants of Vojvodina was 41.8 years, with the male population recording an average age of 40.2 years, and the female population 43.3 years.

Table 4. Age structure of the female population of Vojvodina (2011)

Years of life	Female population	%
Ispod 15	134.953	13,6
15-64	667.531	67,3
65 i više	148.750	15,0
80 i više	40.958	4,1
Ukupno:	992.192	100,0

Source: Statistical yearbook of the Republic of Serbia, 2022

According to the data for the year 2021, the average age of the male population of Serbia was 42 years (which is again less than the national average), and 44.9 years for the female population. According to the data of the Statistical Yearbook (2022), in Serbia there is a numerical dominance of men among the young population, and a dominant participation of women among the middle-aged and old population, which is an unfavorable feature of the age structure of the female population.

When talking about the educational structure, the indicators used are literacy and schooling. According to the results of the 2011 census, in the total number of illiterate persons, the female population recorded a dominant share of around 82%. When it comes to schooling, about 49% of Serbian residents over the age of 15 have completed high school, and only one in six residents has completed higher or higher education.

Although men record a dominant participation among persons who have completed secondary school, women for the first time achieved a higher participation among those with higher and higher education. Among the female population of Vojvodina, the largest number have completed secondary education.

Table 5. Educational structure of the female population of Vojvodina, aged 15 and over (2011)

Educational background	Population	%
No school education	29.416	3,4
Incomplete primary education	117.420	13,7
Primary Education	196.305	22,9
High school	387.164	45,2
Higher education	42.387	4,9
High education	82.061	9,6
Unknown	2.486	0,3
In total:	857.239	100,0

Source: Statistical yearbook of the Republic of Serbia, 2022

In Vojvodina, women with higher and higher education make up 14.5% (124,448) of the female population, and 53.4% among those with higher and higher education in this area (232,874).

The position of women on the labor market

According to data from the Labor Force Survey in the Republic of Serbia (2023), the employment rate of men and women in 2022 recorded an increase, compared to the previous year. It is 43.2% for women and 57.9% for men. If the same indicator is analyzed by type of area, urban and "other" (rural), then it can be seen that the employment rate of men in urban areas is 56.0%, and in "other" 60.3%. Therefore, a higher rate of employment of the male population is recorded in rural areas. When it comes to women, the employment rate in urban areas is 43.8%, and in rural areas 42.4%, which is significantly lower compared to the same employment rate of the male population in the same areas.

The unemployment rate records a decline in 2022 and amounts to 9.8% for women and 9.0% for men. Looking at the type of area, in urban areas the male unemployment rate is 10.3%, and in "other" 7.3%. For the female population, the same rate in urban areas is 10.0%, and in "other" 9.5%. It is noticeable that the unemployment rate of women in rural areas is significantly higher than that of men.

In relation to the year 2021, the rate of the population outside the labor force records a decrease in the year 2022 and amounts to 52.1% in the female population and 36.4% in the male population. According to the type of area, the rate of population outside the labor force in the male population in urban areas is 37.5%, and in "other" 34.9%. For women in urban areas, the same rate is 51.3%, and in "other" 53.2%. All analyzed indicators or rates point to a more favorable position of men on the labor market, compared to women. This difference is especially pronounced in rural areas.

In the region of Vojvodina, the employment rate for men is 59. %, and for women 42.3%. The unemployment rate for men is 8.2%, and for women 8.3%. The rate of the population outside the labor force in the male population is 35.7%, and in the female population as much as 53.9%.

Table 6. Female population of working age (15-64) (2022) (*in thousands*)

Employment Status	2021.	2022.
Active population	361,3	364,5
Employed population	325,2	333,6
Unemployed population	36,1	30,9
Population outside the labor force	230,7	220,0
In total:	**592,0**	**584,4**
Activity rate (%)	61,0	62,4
Employment rate (%)	54,9	57,1
Unemployment rate (%)	10,0	8,5
Rate of the population outside the labor force (%)	39,0	37,6

Source: Bulletin - Labor Force Survey in the Republic of Serbia, 2021, 2022.

A lower employment rate of women, a higher rate of unemployment and a higher rate of the population outside the labor force, compared to men, are indicators of the unfavorable position of women compared to men.

Improving the economic position of women through rural tourism

The results of research on women's interest in entrepreneurship in agribusiness showed that women are dissatisfied with their social position in the countryside and that they perceive their position as subordinate in relation to the opposite sex

(Cvijanović et al., 2011). The theory emphasizes that women play a major role in rural tourism, although this is often less appreciated than men (Arzjani et al., 2011). Nevertheless, the findings that potential female entrepreneurs expressed their willingness to further educate themselves and use non-reimbursed financial assistance are encouraging.

On the other hand, recent research confirms that tourism in rural areas and female rural entrepreneurship have a positive effect on changes in the way and quality of life of women in rural areas (Nedeljković, 2021). The direct economic effects of women's entrepreneurship in the field of rural tourism, as well as activities related to this form of tourism, are the realization of extra profits for women in rural areas, i.e. their economic empowerment. Also, prevention of depopulation of rural areas and achievement of more even development of rural areas and regions in Serbia is highlighted (Radović et al., 2016). Rural women have a special place and potentially represent a strong factor in the overall rural development. Nevertheless, the participation of women in the development of rural tourism in Serbia is assessed as unsatisfactory because it mostly enables the satisfaction of only basic existential needs (Cvijanović and Gajić 2020).

According to the results of an earlier survey of the owners of rural tourist households in the territory of Vojvodina, the majority of respondents indicated pension as the primary source of income, which is related to the unfavorable age structure of the population (Bošković, 2013). For 28% of respondents, pension is the primary source of income, salary was mentioned by 26% and agriculture by 20% of respondents. Only 12% of respondents mentioned tourism as the primary source of income, which indicates an unsatisfactory level of development of this form of tourism. At this level of development, rural tourism cannot independently ensure economic survival for most households. According to the results of the same survey, the largest number of respondents recorded up to 100 visitors/nights during the year (33.3%), with the largest number among them being those with 30 and 100 visitors/nights.

At this level of development of rural tourism, households cannot expect significant economic results or income. One of the respondents of the already mentioned research answered the question of the realized annual net income that it is much smaller than agriculture and that for now it is not enough to make a living or pay off loans (Bošković, 2013). Undoubtedly, insufficient demand is one of the limiting factors. Therefore, we cannot expect a significant impact on the improvement of the economic position of rural women engaged in this activity. Nevertheless, with the strengthening of the development of this activity and the improvement of the quality of the offer, rural women in Vojvodina will be economically and socially empowered. On this path, the state should support all interested women from these areas, both through financial support and through various educations that would contribute to greater interest and motivation.

Conclusion

The availability of quality human resources, especially the female workforce, as well as their motivation to participate in tourist activities will have a decisive influence on the future development of tourism in the rural areas of Vojvodina. Although dominant, the female rural population is aging. The average age of the female population of Vojvodina is 43.3 years. An unfavorable feature of the age structure is that women dominate the middle-aged and old population. As for the educational structure of the female population, secondary education dominates.

The female rural population of Vojvodina has a less favorable economic position compared to the male population. Such a conclusion is based on the lower employment rate of women, the higher rate of unemployment, as well as the higher rate of the population outside the labor force, compared to the male population in the same area. At the same time, such indicators also indicate that rural areas have a female population, a part of which could be engaged in the field of rural tourism.

Considering the current level of development of rural tourism and its economic effects, tourism could represent, above all, one of the sources of income for women and modestly contribute to the improvement of their economic position. With the improvement of the quality of the rural tourism offer, greater support and the realization of more significant economic effects, one can expect greater motivation and more significant participation of women and improvement of their economic position and the quality of their life.

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GENERATIONS ON THE LABOR MARKET - A BIBLIOMETRIC ANALYSIS OF STUDIES IN THE WEB OF SCIENCE

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Abstract

Society is in a continuous transformation, leading to significant changes in the labor market. Although these changes bring many challenges both globally and in Romania, there are also many opportunities for conversion, reinvention and optimization. Globalization, automation, population growth, demographic aging and changes in organizational structures are just some of the factors contributing to a highly unpredictable labor market.

Technological development and education adapted to the digital age have influenced the characteristics of each generation entering the labor market. To understand why and how intergenerational conflict occurs, it is important to know the distinguishing characteristics of each generation. Generational differences can lead to conflict in the workplace.

Recent challenges in the labor market, such as the need to work flexibly or remotely, have required adaptation to new technologies. This has led to an increase in demand for employees familiar with the use of digital skills. Although there is a general trend toward digitization and adaptation to new technologies, Generations Y and especially Z use the Internet to a greater extent than other generations, making them the most important source of information and communications technology (ICT) workers.

This study aims to provide a comprehensive overview of Web of Science publications for the studied area, which allows identifying some of the research directions covered and quantifying the studies by providing information on authors, links, citations, countries, types of studies, and others.

Key words: Labor Market, analysis, bibliometric, Web of Scinece.

Introduction

The diversity of generations in the labor market is becoming increasingly evident, and each generation brings its own characteristics, values and expectations.

Most studies in this area aim to analyze and understand the impact and interaction of different generations of workers on the work environment in order to find effective ways to manage generational diversity, promote cooperation between generations, and adapt to the specific needs and expectations of each generation.

Kryk, B. (2021) states in a study that not all generations represented in the labor market have knowledge-based skills. Each new generation entering the labor market differs from the previous one by differences in education, technology, and the environment in which they grew up (Raiu, 2021). Thus, the distinct and specific character of each generation is shaped by the events that contribute to the formation of fundamental values (Lewis, 2013).

The environment in which a particular generation has developed has a significant impact on its needs and expectations (Bieleń & Kubiczek, 2020), both personal and professional.

An important trend that is emerging with the entry of new generations into the labor market, and not least as a result of digitalization, is the transformation of jobs, organizational structures and the working model in a sense in which flexibility plays an increasingly important role (Nezami et al., 2021).

On the one hand, new perspectives are revealed that enable an increase in the productivity and flexibility of work or even its internationalization; on the other hand, these changes generate pressure to adapt and innovate, to which employees must adapt in order to maintain their relevance on the labor market (Atkinson & Coduri, 2002).

In a labor market with overlapping generational patterns, there are often wage differences between members of different generations (De Palma & Seegmuller, 2005; Shy & Stenbacka, 2018) . These differences may be influenced by factors such as experience level, education, skills, functions performed, and specific job requirements. There may also be differences in the perceptions of value that members of different generations bring to the table, which may contribute to salary differences.

Studies highlight the fact that the last two generations entering the labor market meet the requirements of a modern labor market (Kryk, 2021), which favors flexible work models thanks to technology-based knowledge (Grencikova et al., 2016).

The offer of jobs from employers seems to better reflect the employment demand of young people, who often occupy jobs with higher education where they put in little physical effort (Bugudui, 2015), but due to the fact that they change their jobs quite often often, the two younger generations present in the labor market are seen as less loyal than previous generations (Grencikova et al., 2016).

As the baby boom generation has aged, unemployment and dependency ratios have risen (De la Croix et al., 2013). Thus, in countries with a continuously shrinking population, where the demographic aging index has increased significantly in recent years, the transfer of knowledge and skills between generations becomes more valuable than ever (Niță, 2016).

Considering all of the above, this study aims to provide a perspective on the Web of Science publications related to the analyzed field, with the goal of identifying the research directions addressed in this field and quantifying the available studies by providing detailed information on authors, links between studies, citations, country distribution, research types, and other relevant aspects. By analyzing this information, it is hoped to gain a deeper understanding of the evolution of research related to generations of workers in the labor market and to identify potential emerging trends and significant contributions in this field.

Results and Discussions

To select the most relevant studies in this area, we performed a bibliometric analysis using the Web of Science academic platform as the main source of scientific articles. The search results returned 355 research articles dealing with the topics of "generations" and "labor market". To obtain a more detailed understanding of the structure of the scientific field, we performed a content analysis using the VOSviewer program to examine the most frequent words and the relationships between them.

In the first phase of the bibliometric analysis, we identified the top 10 Web of Science categories in which most publications appeared during the period studied (Table 1; Figure 1). Significant author interest in economics can be observed, with a focus on aspects of sociology, social sciences, education and research, and demography.

Table 1. Main WOS categories

No.	Web of Science Categories	Record Count	% of 355
1	Economics	156	43.94
2	Sociology	45	12.68
3	Social Sciences Interdisciplinary	29	8.17
4	Education EDUCATION Research	25	7.04
5	Demography	24	6.76
6	Business	22	6.20
7	Business Finance	21	5.92
8	Management	21	5.92
9	Gerontology	13	3.66
10	Industrial Relations laboratory	12	3.38

Source: Author's calculations based on WOS data

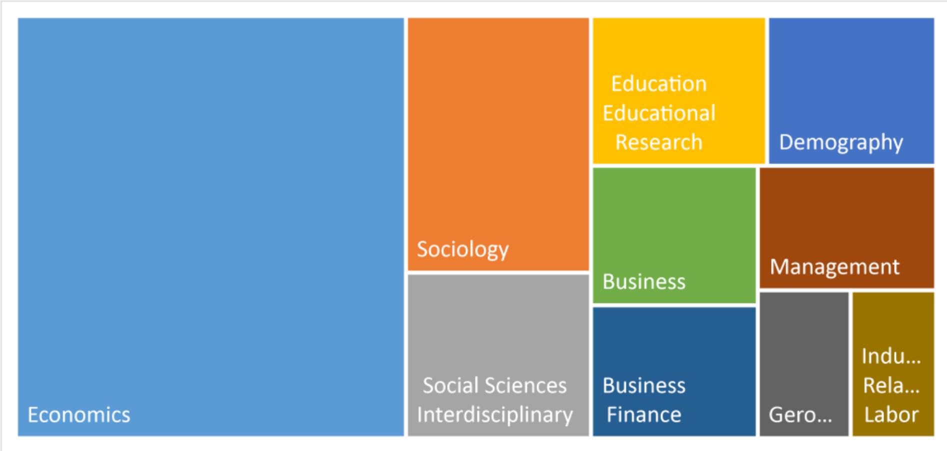

Figure 1. Main WOS categories

Source: WOS database

According to the data available in the WOS database, in terms of the distribution of scientific production over the last 30 years, there is an upward trend with slight fluctuations (table 2). Between 1992 and 2022, the number of works that addressed the analyzed topic increased significantly (figure 2).

Table 2. Publication years of WOS documents

No	Publication Years	Record Count	% of 355	Evolution compared to the previous year %
1	2022	25	7.04	-13.79
2	2021	29	8.17	-23.68
3	2020	38	10.70	-20.83
4	2019	48	13.52	45.45
5	2018	33	9.30	50.00
6	2017	22	6.20	-12.00
7	2016	25	7.04	177.78
8	2015	9	2.54	-30.77
9	2014	13	3.66	-27.78
10	2013	18	5.07	125.00
11	2012	8	2.25	14.29
12	2011	7	1.97	-46.15
13	2010	13	3.66	0.00
14	2009	13	3.66	225.00
15	2008	4	1.13	0.00
16	2007	4	1.13	33.33
17	2006	3	0.85	-50.00
18	2005	6	1.69	100.00
19	2004	3	0.85	50.00
20	2003	2	0.56	-66.67
21	2002	6	1.69	-33.33
22	2001	9	2.54	80.00
2. 3	2000	5	1.41	150.00
24	1999	2	0.56	0.00
25	1998	2	0.56	0.00
26	1997	2	0.56	100.00
27	1996	1	0.28	-50.00
28	1995	2	0.56	0.00
29	1994	2	0.56	100.00
30	1992	1	0.28	

Source: Author's calculations based on WOS data

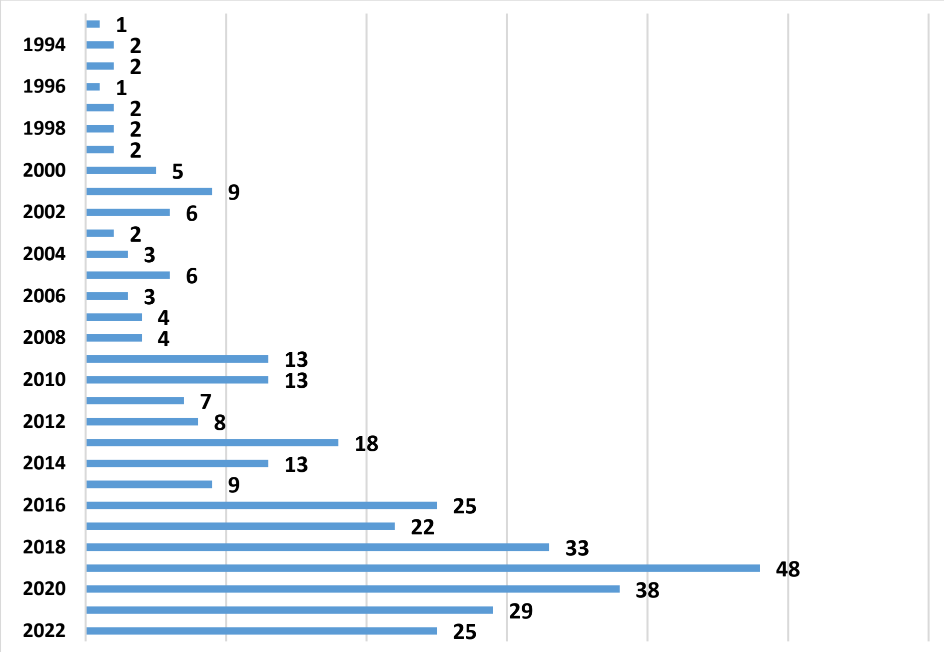

Figure 2. Annual evolution of publications in WOS (1992-2022)

Source: Author's own research based on Web of Science

This study analyzed 355 research papers written by a total of 770 authors from 51 countries (Figure 3), belonging to 497 institutions such as universities, research institutes, laboratories, nongovernmental organizations, national libraries, associations, and government institutions.

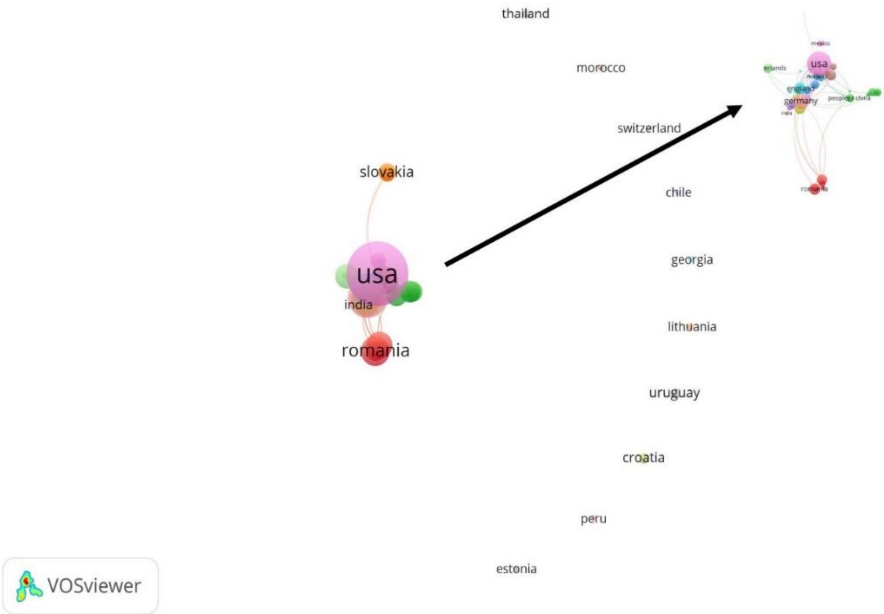

Figure 3. Network map of all 51 countries

Source: Author's own research based on Web of Science in VOSviewer

The data reveal a particular interest for research in countries such as Germany, Romania and others (table 3). These countries are motivated to identify and implement sustainable solutions that contribute to achieving the goals set in the 2030 Agenda.

Table 3. Country of publication

No.	Countries	Record Count	% of 355
1	USA	98	27.61
2	Germany	42	11.83
3	England	24	6.76
4	Romania	21	5.92
5	French	20	5.63
6	Spain	18	5.07
7	Sweden	18	5.07
8	Canada	17	4.79
9	Netherlands	14	3.94
10	Belgium	12	3.38

Source: Author's processing based on data from WOS

Based on the sample of 355 works selected from WOS, an analysis of the distribution of scientific production in the last three decades was carried out, namely the number of citations compared to the number of publications, noting the upward evolution of the number of citations. This follows the same pattern in terms of the number of publications per year described in the previous section.

Based on the sample of 355 papers selected from the Web of Science , we performed an analysis of the distribution of scientific production in the analyzed years, in terms of the number of citations compared to the number of publications (Figure 4). Although this analysis indicates that the works in the sample were well received, generating increased interest, thus contributing to the progress and development of research, starting from the pandemic year 2020, a slight decrease in this indicator is observed.

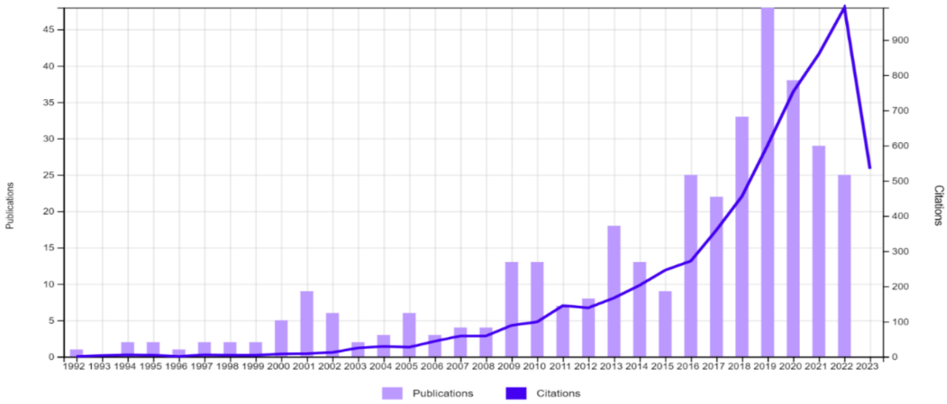

Figure 4. WOS – Citation Analysis

Source: WOS

In the next step of the analysis, we performed a term co -occurrence analysis for the sample of research published to date.

To select the most relevant studies in the field, we used a bibliometric analysis , the main source of scientific articles chosen being the academic platform Web of Science . We explored the content of 355 research articles related to generations, and the labor market. To highlight the structure of the scientific domain, we used a content analysis, inspecting the most common words and the relationship between words.

In this part of the research, we approached a co -incidence analysis of the keywords to identify frequently studied topics in relation to the terms searched for in the analysis, namely " generations " and " labor market", as well as the relationships between them.

The reason behind a keyword co -occurrence analysis is best explained by (Zupic & Čater, 2015): “When words appear frequently in documents, it means that all these concepts behind the words are closely related. The result of the analysis is a network of themes and their relationships that represent the conceptual space of a field”.

keyword co -occurrence analysis using the VOSviewer program allowed us to identify frequently addressed topics related to the search terms in the analysis.

co -occurrence map is generated based on 1649 keywords found in the 355 documents in the database. Of these, 34 meet the threshold of having a minimum number of 10 occurrences. The keyword co -occurrence map visualizes two things: keywords that appear frequently, based on their prevalence, and how keyword popularity/frequency changes over time (figure 5).

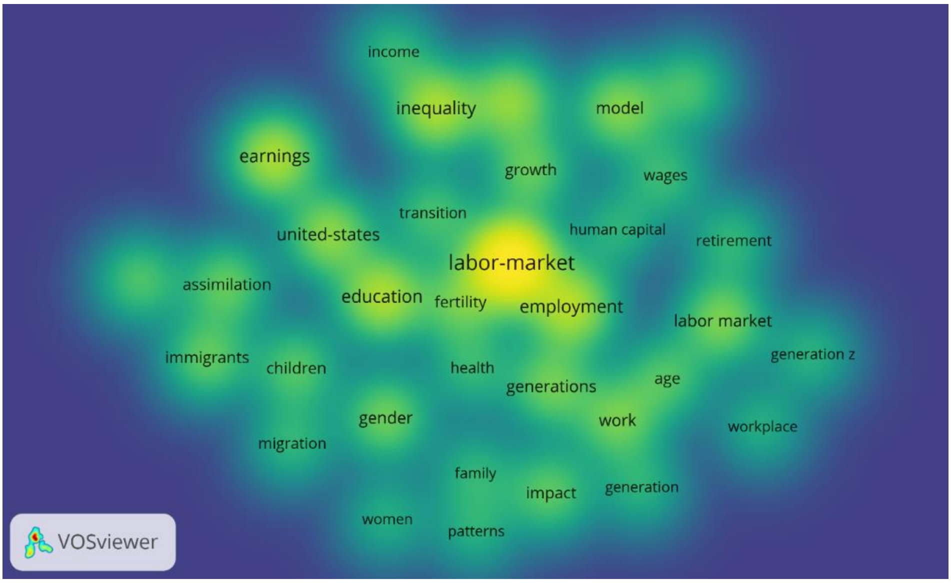

Figure 5. The most used keywords in scientific publications related to: generations and labor market

Source: Author's own research based on Web of Science in VOSviewer

The software VOSviewer generated 4 clusters (figure 5) for keyword occurrence analysis. Clusters range in size from 12 items in the larger red cluster to 5 items in the smaller yellow cluster. This number of clusters was generated because in our database we did not limit the articles according to their field of research and there is a variety of work related to generations and the labor market, from different fields from economics and sociology to demography and management.

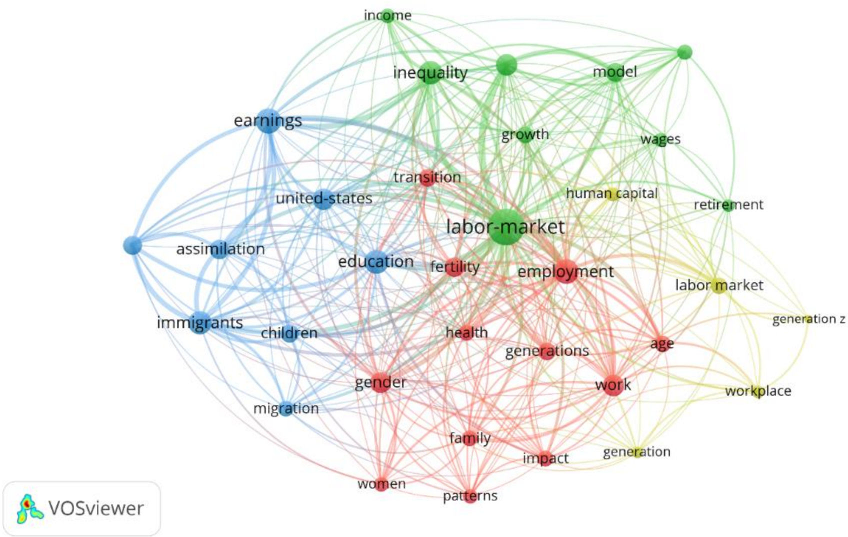

Figure 6. Keyword co-incidence map for scientific publications related to: generations and the labor market

Source: Author's own research based on Web of Science in VOSviewer

The red cluster in figure 6 is the largest cluster and generally groups keywords such as: gender, generations, age, transition (figure7). The keywords with the highest number of occurrences are "gender" with an occurrence of 21 times and a total link strength of 52. Another keyword in the red cluster is "generations" with an occurrence of 21 and a total link strength of 39.

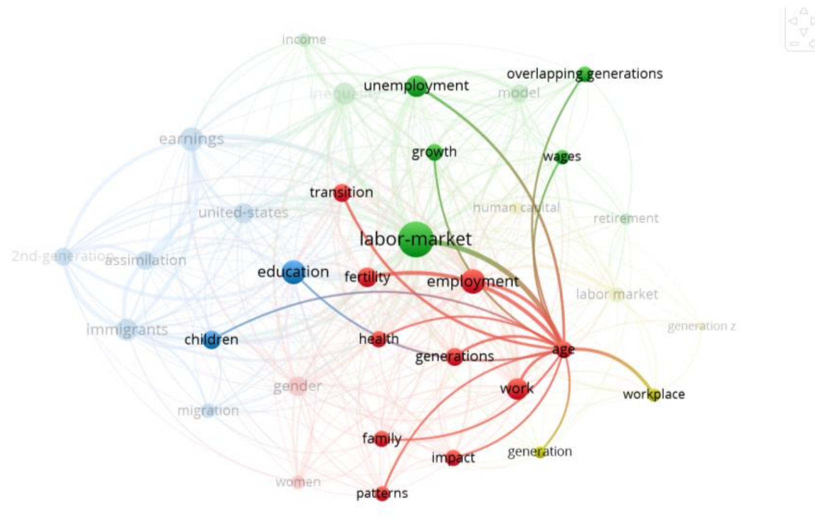

Figure 7. Keyword co-occurrence map for scientific publications related to: generations and the labor market

Source: Author's own research based on Web of Science in VOSviewer

Depending on the number of elements, the second cluster in figure 6 is the green one, which groups 9 elements (figure 8). The keywords in this group are the most highlighted on the map, being located in the middle of the map. The most used keyword in our sample of papers is "labour market", with a co -incidence of 70 times and a total link strength of 161. Another important keyword is related to the first, namely "inequality", with 31 occurrences and a total link strength of 67. Another keyword of this group is "model", with 24 occurrences and a total link strength of 44.

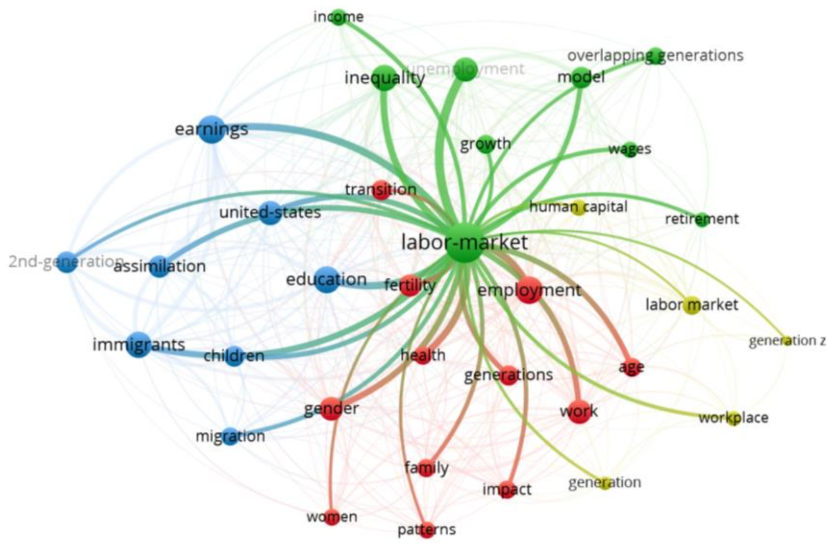

Figure 8. Keyword co-occurrence map for scientific publications related to: generations and the labor market

Source: Author's own research based on Web of Science in VOSviewer

The blue cluster in figure 6 highlights the importance of population in this study, the frequently mentioned words being migration, emigration, education, earnings (figure 9).

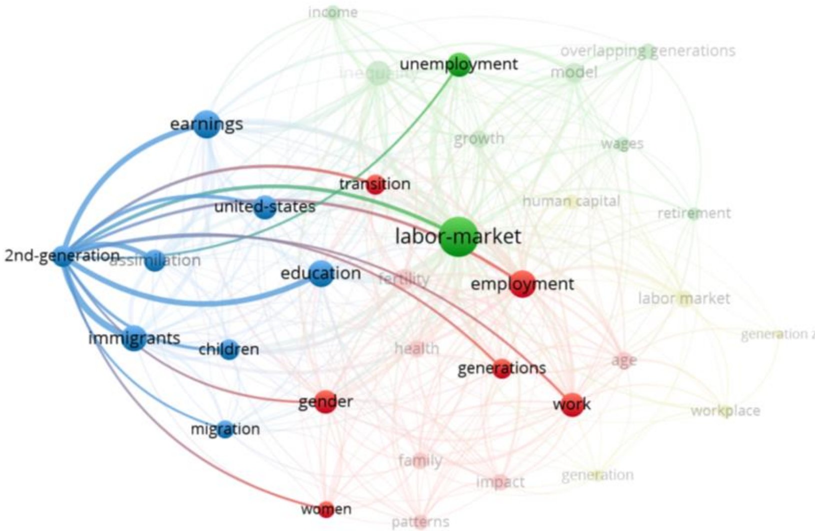

Figure 9. Keyword co-occurrence map for scientific publications related to: generations and the labor market

Source: Author's own research based on Web of Science in VOSviewer

The yellow cluster in figure 6 highlights the existing links between generations, human capital and the labor market (figure 10).

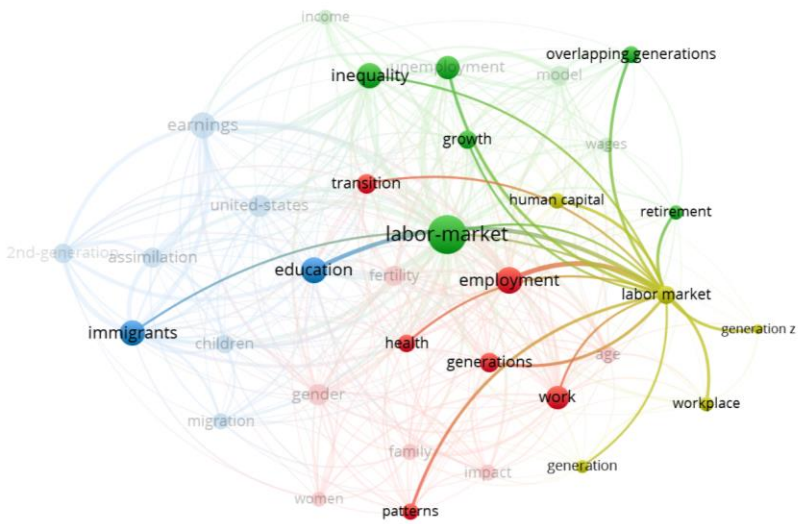

Figure 10. Keyword co-occurrence map for scientific publications related to: generations and the labor market

Source: Author's own research based on Web of Science in VOSviewer

Among the authors with the most citations that we find in figure 11, we mention Corak, Miles (695 citations); Urdal, Henrik (366 citations); Dustmann, Christian (331 citations); Storesletten, K (301 citations); Telmer, Ci (301 citations) and Yaron, A (301 citations).

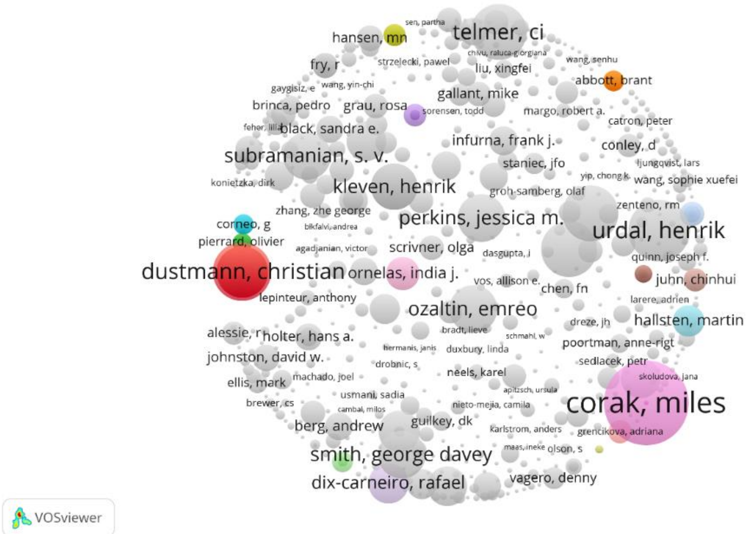

Figure 11. Network map of 712 authors by citations

Source: Author's own research based on Web of Science in VOSviewer

Conclusions

Over time, the topic of "generations in the labor market" has attracted the interest of researchers and led to a number of studies and debates on how different generations of workers, such as the Baby Boomer generation, Generation X, Generation Y (Millennials), and Generation Z, interact in the labor market, including their values, expectations, skills, and attitudes toward work and careers.

As a result, the importance of the topic under study increased, reaching the peak of publications in the Web of Science in 2019. After 2019, with the outbreak of the Covid 19 pandemic, interest in the topic of the current study decreased. With the outbreak of the pandemic, public attention and research have largely focused on the health aspects and economic impact of the pandemic. On the other hand, the pandemic has brought significant changes in the way people work and learn. This may have altered research priorities, leading to a reduction in interest in other topics.

In summary, the labor market is subject to constant change and success depends on the ability of individuals and companies to adapt to these changes and take advantage of the opportunities that arise.

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THE INFLUENCE OF THE QUALITY OF THE OFFER OF TOURIST PRODUCTS ON THE DEVELOPMENT OF RURAL TOURISM IN THE ZAJEČAR DISTRICT

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Abstract

In recent years, the topic of the quality of the offer of tourist products in rural tourism has assumed great importance. As the development of rural areas increasingly depends on rural tourism, and the quality segment deserves more attention from rural tourists, there is a need to study, monitor and improve the quality of the offer. The paper, after presenting the rural tourism of Eastern Serbia and the concept of quality in rural tourism, analyzes quality of the offer of tourist products in rural tourism of the Zaječar District. The evaluation of the quality relies on the subjective, i.e. personal perception of the products/services of people familiar with the rural tourism offer and the owners of rural tourist households. The quality of the offer was assessed as "satisfactory", and it was determined that there is room for further development and improvement of the offer of rural tourism in mentioned district, which would encourage the development of the village.

Key words: Rural development, rural tourism, tourist product, quality, Zaječar District.

Introduction

In the last few years, within the tourism and travel industry, rural tourism has seen significant development, reflecting the ever-growing need of people to stay in rural, peaceful, healthy environments and take a break from everyday dynamic life. World Tourism Organization (WTO) considers rural tourism as a form of tourism that includes any tourist activity in rural areas, organized and managed by the local population, relying on local tourist resources and tourist facilities (Gašić et al., 2015). Based on the definition of rural tourism, it can be seen that it takes place in a rural area. Rural areas could be defined as areas with a small population concentration, whose main occupation is agriculture, characterized by a special way of life, work, customs and village identity (Cvijanović, Ružić, 2017). Rural tourism is often correlated with the development of the country's economy and agriculture. Accordingly, in recent years, the offer of rural tourism in the Republic of Serbia has recorded positive growth, with the quality of tourist products in rural tourism playing a significant role in its development.

The growth of interest in research of quality of rural tourism is a consequence of the mentioned development of rural tourism. Rural destinations increasingly depend on quality, which is why the quality of services has become an important element in the business of rural tourist households (Choi et al., 2018). Understanding service quality is more complex than understanding product quality. In order to define the concept of service quality, it is necessary to start with the consumer and how he understands and interprets quality (Drinić et al., 2014). Quality in rural tourism is primarily ensured by the natural and social characteristics of rural areas, a rich and affordable offer in rural tourism, while from the perspective of service users quality can be measured through the level of quality of facilities and capacities for providing catering services, agricultural food products, and home-made products that are offered, the hospitality of the local population, and opportunities to participate in peasant affairs.

The paper aims, first of all, to briefly present the rural area and the level of development of rural tourism in Eastern Serbia, and the rural tourism offer of the Zaječar District. Then, to present the concept of quality in rural tourism. Finally, to investigate the quality of tourist products in rural tourism of the Zaječar District and indicate the influence of the quality of the offer on the development of rural tourism, which further contributes to the development of rural areas.

Development of rural tourism in Eastern Serbia and the Zaječar District

The wealth, preservation and attractiveness of natural resources, a large number of traditional agricultural households, the gradual increase in the living standard of the domestic population, as well as the increasing interest of the international tourist market in rural tourism experiences, are a fairly solid basis for the development of rural tourism in the whole of Serbia, especially in its southwest and southeastern part (Manić, 2014).

Rural areas in Serbia differ economically, socially and demographically. The difference is conditioned by their geomorphological characteristics (mountainous, hilly, plain areas), changes in the number of inhabitants, economic structure, infrastructure, environmental conditions, traffic availability. In an effort to identify their strengths and weaknesses, a typology of rural areas was created through cluster analysis, as a part of the preparation of the Rural Development Strategy Plan (Matijašević et al., 2014). According to the mentioned typology, the east of Serbia with the Zaječar District belongs to the group "predominantly mountain economy oriented on natural resources". It is basically a rural region with unused natural resources and tourism potential (Gašić, 2016). Active work on rural tourism development strategy, of the mentioned area, would bring significant benefits to all parties involved in the tourism economy, preservation of the rural environment and raising the standard of living of the rural population. Agritourism and rural experience in a rural environment stand out as the most characteristic tourist product of Eastern Serbia (Manić, 2014), which represents the foundation for brand building in the future. At the level of the agricultural household, agritourism is connected with the rural environment, agriculture and local craftsmanship (Veljković and Broćić, 2017).

According to the Census of Agriculture from 2012, in the region of Southern and Eastern Serbia were officially registered 187.796 agricultural farms. Within Eastern Serbia, specifically the Zaječar District, that number amounts to 16.675 agricultural farms. A large number of agricultural farms are included in tourism economy, respectively they perform tourism as a secondary activity within their farms. As agricultural farms represent the carrier of rural tourism and rural development, it can be said that rural tourism in the east of the country is in the initial stage of development. The increasing interest in investments in rural tourism speaks to its development.

The area of the Zaječar District is rich in natural and social values, which enable the development of rural tourism. When talking about the offer of tourist products in rural tourism of the Zaječar District, it can be said that it is rich and diverse. The offer of rural tourism is represented by facilities and capacities for the provision of catering services, and the types of services and products that are offered and sold to rural tourists (Cvijanović, Ružić, 2017). At the district level, there are 111 facilities and capacities for catering services (based on data from tourism organizations of the Zaječar District). The offer of agricultural food products in the Zaječar District is dominated by fruit products, especially cherries, given that a large part of agricultural farms are engaged in their cultivation, followed by honey and medicinal herbs. There is also a wide range of home-made products, which are made with motifs characteristic for the Timočka Krajina. The local population makes it possible to carry out village activities and learn about different peasant affairs.

The interest in rural tourism is constantly rising due to the existence of still attractive and "unspoiled" rural areas with a well-defined way of life, culture and customs, the great need to preserve such areas, to provide the population with the possibility of income through tourist services, and the preservation of original services and products by creating offers for a different vacation (Baćac, 2011). Agricultural production, preservation of agricultural resources and development of rural tourism as a supplementary activity of people living in the countryside should be one of the most important goals of rural development (Petrović and Grujović, 2015).

The concept of quality in rural tourism

In the literature where quality appears, there are different approaches to define the concept of quality, in which there is a lot of subjectivity of those who evaluate it, and the approaches that dominate today in defining quality are aimed at meeting the needs and expectations of consumers (Barjaktarović and Knežević, 2021). Service quality can be defined as the difference between consumer/tourist expectations and perceptions of the delivered service (Parasuraman et al., 1985).

In context of the service industry, and therefore at the level of a tourist destination, quality is created through three dimensions: processes, physical environments and results. The first dimension refers to personal interaction, the second focuses on the characteristics of the processes themselves, while the third dimension concerns the results ensuing from the respective processes (Brady and Cronin, 2001).

Prominent attention is paid to the quality of services in rural tourism, considering that the generation of income depends on how well service providers in rural tourism deliver their service. Rural tourist destinations are increasingly dependent on quality, which is why the quality of services has become an important element in the business of rural tourist households, bearing in mind that quality is a significant predictor of satisfaction that further leads to loyalty (Choi et al.,, 2018). Establishing quality in rural tourism is a key requirement for meeting the needs of visitors, which in return should provide a business advantage in an increasingly competitive market (Gašić et al., 2015).

When talking about the quality of services of a rural tourist destination, the factors that contribute to the success of the cognitive component are: the characteristics of the rural destination itself; offer of services; additional services that depend on the rural tourist destination itself (Peña et al., 2012). The limiting factors of the development of rural tourism are manifested in the lack of quality service, infrastructure, facilities and control over the use of resources (Gašić et al., 2022).

Seen from the perspective of tourists, it is evident that there are growing demands for service quality in rural tourism, and this can be seen as one of the most important development points of this type of tourism (Kumra, 2008). The rural tourism experience can be positive or negative and is not only related to the quality of tourist attractions, but also the quality of service and care for tourists (Amoah and Amoah, 2019).

It is extremely complicated to compare the quality of the facility, i.e. the products and services offered by a rural household or home-made facility, with the services offered by a hotel, villa or resort. For this reason, and based on examples of good practices and experiences from European countries, the European Federation for Farming (Agrotourism) and Rural Tourism (abbr. EuroGites) has established unique standards for assessing the quality of accommodation units in rural areas. The criteria of established standards are grouped into five clusters: equipment of the agrotourism accommodation units; environment of the agrotourism accommodation units; services in the agrotourism accommodation unit and its surroundings; dedication to the guest, privacy and ambience in the agrotourism accommodation unit (intangible aspects); security and safety in the agrotourism accommodation units. In recent years, EuroGites standards have been explained and applied by many authors in contemporary scientific references. It was established that these standards are an extremely effective instrument for analyzing a large number of aspects of the quality of the offer, and accordingly they are very applicable in the most diverse rural areas (Petrović et al., 2015).

Empirical research

The subject of the research is the analysis of rural tourism in the Zaječar District, where the emphasis is placed on examining the quality level of the offer of tourist products.

The aim of the research is to determine the level of quality of tourist products in rural tourism of the Zaječar District. While determining the previously mentioned, an evaluation of the answers of the respondents was carried out, i.e. an evaluation of their assessment of the quality of the offer in rural tourism of the Zaječar District, which relies on the subjective, i.e. personal perception of products/services of rural tourists, visitors to the rural area, residents familiar with the rural tourist offer as well as owners of rural tourist households.

Methodological framework

Primary sources of data were used in the research (in the process of data collection a quantitative approach to surveying the public was used). Empirical research was conducted through a survey questionnaire on a sample of 54 respondents and 12 rural tourist households in the period of June 2023. Questionnaires were distributed in written and electronic form to respondents. The methods used in processing the collected data are descriptive statistics and correlation analysis.

Results

Table 1. Analysis of the offer components in rural tourism of the Zaječar District (*n=54*)

Attitude of the respondents		**Frequency**	**AM* of the quality score (1-5)****
Contribution of natural values to the quality of the offer of rural tourism	Yes	52	3.89
	No	2	
Contribution of social values to the quality of the offer of rural tourism	Yes	51	3.78
	No	3	
Hospitality as an important component of the quality of the offer in rural tourism	Yes	51	3.69
	No	3	
Agricultural food and home-made products as components of the quality of the offer in rural tourism	Yes	49	3.83
	No	5	
Authenticity of accommodation facilities and capacities for catering services in rural tourism	Yes	52	3.59
	No	2	

**AM – Arithmetic Mean*

***1 indicates "unsatisfactory quality" and 5 "extremely satisfactory quality"*

Source: Author's research

Based on what is shown in Table 1, it is possible to conclude that the natural and social values contribute to the quality of the rural tourism offer, that the hospitality of the local population and the offer of agricultural food and home-made products are rated as significant components of the quality of the offer in rural tourism, and that the accommodation facilities and capacities for the provision of catering services in rural areas of the Zaječar District is characterized by an authentic (traditional) style of construction. The quality of all the mentioned components was evaluated with average marks between 3,59 and 3,89.

Table 2. Analysis of the quality of the tourist offer in rural tourism of the Zaječar District (*n=54*)

Quality component	AM* (1-5)**	SD***
Tourist offer in rural tourism	3.59	0.714

**AM – Arithmetic Mean*
***1 indicates "unsatisfactory quality" and 5 "extremely satisfactory quality"*
**** SD – Standard deviation*

Source: Author's research

The average rating of the overall quality of the offer in rural tourism of the Zaječar District is 3,59.

Determining the existence of a correlation between the quality of the offer of tourist products in rural tourism and the quality of accommodation facilities and capacities for the provision of catering services in rural areas was carried out with the help of correlation analysis.

Table 3. Correlation analysis

Variables	The quality of facilities	The quality of the offer
The quality of facilities	1	0.638**
The quality of the offer	0.638**	1

***Correlation is statistically significant at the 0.01 level.*

Source: Author's research

The results of the correlation analysis show a high degree of correlation between the quality of the offer in rural tourism and the quality of facilities and capacities for catering services (0.683).

The research includes an examination of the quality of rural tourist households in the Zaječar District, based on the EuroGites standards for assessing the quality of services in agrotourism, adapted to the needs of the research.

Table 4. Analysis of the quality of rural tourist households in the Zaječar District (*n=12*)

Clusters	AM** of the quality score (1-5)***
1 Equipment of the AAU*	4.60
Local style of construction	3.92
Preservation of the object	4.75
Traditional/authentic equipment	3.92
Cleanliness	4.92
Room equipment	4.83
The quality and comfort of the rooms	4.75
Size of common rooms	4.67
Lighting/windows	5.00
Bathroom (min. equipment)	4.92
Supply of running water	4.92
Hot water supply	5.00
Room heating	5.00
Air conditioning of the rooms	3.25
2 Environment of the AAU*	4.55
The rural environment in which the facility is located	4.50
Prevention of impact/disturbance (unpleasant smells, noise)	4.75
Resources 1 (natural)	4.58
Resources 2 (social)	4.17
The level of preservation of the natural environment	4.67
Contribution to local development	4.58
Social and cultural responsibility	4.58
Advising local stakeholders	4.58
Responsibility towards the environment	4.58
3 Services in the AAU* and its surroundings	4.56
Room maintenance	5.00
Provided meals in the accommodation unit	4.50
Local gastronomic offer	4.75
Recreational opportunities within the accommodation unit	3.67
Recreational opportunities in the area	4.58
Access to the building/signposts	4.67
Information for tourists	4.50
Accommodation information/instructions	4.83
4 Intangible aspects	4.70
Professional qualification of the host	4.42
Welcoming the guest	4.92
Introducing the guest to the local offer	4.83
Commitment to the guest during the stay	4.58

Ability to communicate in a foreign language	4.50
Privacy in the rooms where guests stay	4.92
5 Security and safety in the AAU*	4.89
Insurance (for social responsibility)	4.83
Protection against fire and other accidents	4.83
Harmonized tourist prescribed conditions	4.92
Control of adequacy of technical and other equipment	4.92
Health conditions	4.92
Reservation guarantees	4.92
Consumer protection (complaints, defined procedures)	4.75
Exposure of the price list	5.00

**AAU – Agrotourism accommodation units*
*** AM – Arithmetic Mean*
***1 indicates "unsatisfactory quality" and 5 "extremely satisfactory quality"*

Source: Author's research

The quality of rural tourist households was assessed with extremely high average scores at the cluster level. The ratings are based on the opinions of the owners of rural tourist households about their quality.

Discussion

By researching the quality of the offer of tourist products in rural tourism of the Zaječar District satisfactory results were obtained. The influence of the quality of the offer on the development of rural tourism is great, and considering the offer's satisfactory quality, the mentioned district has all the predispositions for advancement in rural tourism. A rural household that bases its services on quality, stands out in the competitive tourist market. As the quality of the offer of rural tourist households is at a high level, agrotourism can become recognizable as the backbone of the future development of the Zaječar District. Ways to help the development of agrotourism in the mentioned region are encouraging the practice of rural tourism with adequate support, stakeholder investment, and forming partnerships. Promoting agrotourism enables the sustainable development of rural areas and improves the rural area as well as life in the countryside.

Conslusion

There are a large number of tourists who temporarily want to embrace the rural way of life and lifestyle. Based on that, there is a demand for a certain level of quality that is present in everyday life. That is why quality management and its importance for the competitiveness of rural tourist destinations is becoming an increasingly studied area.

By investing in rural tourist destinations and providing a quality offer within them, the development of rural tourism is promoted, which further prevents the degradation of villages and enables solving numerous problems of rural communities.

Based on the research, it was determined that, considering the diversity and attractiveness of the offer of satisfactory quality, it is necessary to help the further development of rural tourism in Eastern Serbia and the Zaječar District. Subsequent research should be carried out in administrative districts throughout the regions of Southern and Eastern Serbia, where knowledge about the quality of the offer and the state of development of rural tourism in this part of Serbia would be gained, but would also enable a comparative measurement of the results. It is important to mention that further research can also lead to the spread of awareness of the importance, the need to define and present the unique rural offer of the region of South and Eastern Serbia, and then the unique offer of rural tourism in the Republic of Serbia, which would raise the development of the village and the care of the village to a higher level.

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FARMSTEAD TOURISM: EXAMPLES OF GOOD PRACTICE IN VOJVODINA

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Abstract

Farmstead tourism is a special form of rural tourism, which represents a well-developed, promoted and popular rural tourist product, both on the domestic and international tourist markets. Farmstead tourism is characteristic for the area of Vojvodina, and its development requires a connection with agriculture, the preservation of cultural and historical heritage, as well as an authentic gastronomic offer. The aim of the work is to present the importance of farmstead tourism for the development of rural tourism in the area of AP Vojvodina, as well as to present examples of good practice, i.e. farms with the longest tradition and best results in tourism.

Key words: rural tourism, farmstead tourism, development, agriculture, AP Vojvodina.

Introduction

There are numerous advantages for the development of rural tourism in the Republic of Serbia, among which the great geographical diversity of the landscape is particularly significant, from the Pannonian Plain, which is located in the northern part of Serbia, through the hilly and mountainous regions in central Serbia, to the typically mountainous area in the south of Serbia, which together enables the development of a diverse tourist offer (Vuković, Subić, 2019). In the area of the Pannonian Plain, in Vojvodina, there are good conditions for the development of farmstead tourism, as a special form of rural tourism, which is directly related to the cultural and historical heritage of this area, as well as to agriculture.

Rural tourism is the most heterogeneous type of tourism considering that, according to the results of previous research, there are over 50 different forms of this tourism (Radović, 2015). Farmstead tourism is a special form of rural tourism, which represents a well-developed, promoted and popular rural tourist product, both on the domestic and international tourist markets. Through farmstead tourism, it is possible to sell agricultural and food products at higher prices than in traditional markets, but also to sell products of old crafts and handicrafts. Together, this enables the creation of new jobs and the valorization of women's work in rural households, the provision of additional income to residents of rural areas, as well as overall rural development (Radović, 2018).

The word "szallas – farmhouse" is of Hungarian origin, and it means an agricultural farm with an organized economic yard (for agricultural production), built residential and production facilities, fenced with wire or a hedge (Gavrić, 1994). Farmsteads are a kind of urban and architectural entity that has survived for hundreds of years. The traditional specific values of the farmstead are its appearance, household, cuisine and way of life. In the past, the farmsteads were without water, electricity and with old traditional furniture (Košić, 2012).

Essentially, a farmstead is best defined by three essential elements: work, housing and field, i.e. the absence of any of them "negates the concept of a farm" (Gajinov, 1994, p. 203). Farmstead represent a special way of life and economic management that is characteristic of agricultural production in Vojvodina. Observing throughout history the number of farmsteads and the number of inhabitants on them, we can state that the production of livestock and agricultural products that they achieved was very important for the supply of the cities in the vicinity of which they were locate. With the intensification of agricultural production, farmsteads began to lose their importance (Košić et al., 2013).

Farmsteads began to be built in the area of Vojvodina in the middle of the 18th century, and most of them were built in the second half of the 19th century, as well as in the first decades of the 20th century. Before the First World War, there were about 11,000 farmsteads in the area of Vojvodina. The most numerous were in Bačka and northern and central Banat (Stojanov, 1994). Today, a small number of farmsteads are in operation. According to (Subić, 1994), the disappearance of farmsteads is conditioned by demographic factors, as well as economic reforms that occurred after the Second World War. The disappearance of farmsteads is conditioned by the characteristics of the modern way of life, as well as the urbanization of society. Of the remaining farmsteads, many have been turned into real tourist oases (Pejanović, 2013).

The revitalization of farmsteads, in order to develop tourism, can have multiple positive effects. Positive effects can be: economic, demographic, ecological, cultural, infrastructural, communal, stimulating for the development of economic activities related to tourism (Dragićević, 2007). In order to develop rural tourism, it is necessary to provide the traditional features that tourists expect in rural areas, namely: regional features of traditional architecture, traditional interior decoration, traditional garden with agricultural holdings, organic agricultural production, regional gastronomic and eno-gastronomic offer, as and traditional togetherness in the tourist performance of farmers engaged in rural tourism (Kušen, 2007). We believe that all of the above is particularly important for the development of farmstead tourism.

Between the development of rural areas, especially agrotourism, and the development of agriculture, that is, the production of agricultural and food products, there is a mutual connection (feed back). The authors (Jeločnik et al., 2020) conclude that agricultural farms that have their own production of agricultural and food products, which they market through the agro-tourism offer, in this way initiate an increase, i.e. stabilization of income, and thus the sustainability of the agricultural farm's profits. We are of the opinion that the above conclusion is of particular importance for the development of farmstead tourism.

Rural, as well as farmstead tourism, is a form of rural entrepreneurship that can initiate the development of rural economies and the growth of the employment rate of the rural population, given that it is a labor-intensive activity. Its impact on the development of rural economies is derived from the multiplicative impact of tourism on the development of the economy. In order to develop farmstead tourism, it is necessary to develop authentic tourist content based on tradition, as well as adequate promotion of this tourist product and quality sales channels (Radović et al., 2015). Also, for the purpose of development, in the coming period, more significant financial support from the state is needed in order to affirm farmsteads and develop rural tourism, and thus rural development in the area of AP Vojvodina (Pejanović et al., 2014).

Methodology

The aim of the work is to present the importance of farmstead tourism for the development of rural tourism in the area of AP Vojvodina, as well as to show examples of good practice, i.e. farmsteads with the longest tradition and best results in tourism. The paper uses a field research, descriptive method, as well as an analysis and synthesis method.

Research results - examples of good practice

Based on the results of field research, authentic Vojvodina farmsteads are presented in this chapter, which have the longest tradition in tourism, but are also the most famous on the tourist market, i.e. record the highest number of visits and overnight stays by tourists**.**

Farstead 137

Farmstead 137 is the first farmstead that opened its doors to tourists, and represents the first tourist farmstead in the area of Vojvodina. Farmstead got its name from the postal code, it is located in Čenej, a village 10 km from Novi Sad. The first tourists arrived at this farmstead in 1998, and since then it has been working continuously and developing its specific tourist offer. The founder and owner of the first tourist farmstead in Vojvodina, Aleksandar Samardžija, believes that the most important thing for modern tourists is the silence and peace they find on farmsteads. It is extremely important that the catering offer includes traditional food from this area – „*salash food*“, and it is also necessary to respect the "*salash customs of life*". Then the effect is guaranteed for both domestic and foreign guests, i.e. the quality of the farmstead tourism offer is achieved.

Agricultural activity – The development of tourism took place in parallel with the development of agriculture, as the basis and essence of farmstead tourism. For years, the income from the tourist activity was invested in the expansion of the property, which today covers 10 hectares, of which 7 hectares are cultivated. The farmstead produces fruits, vegetables, but also soybeans, wheat, corn, barley, etc. In this way, fresh food for catering, as well as food for domestic animals, is provided from its own agricultural production.



1. 2. 3.

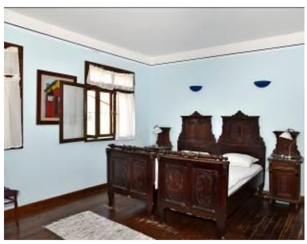
The layout of the house in which there are accommodation facilities, on the farmstead there is a „đeram“ and numerous domestic animals

Source: Photo, G. Mulić

Tourist activity – Farmstead 137 has 12 double rooms, each with its own bathroom. Three rooms are located in the former "biroška", i.e. a house where people lived who helped the owners with agricultural work. The remaining accommodation facilities were built on the area where the pigsty and the chicken coop used to be. In almost all rooms there are clay stoves, which are fired with solid fuel and which give the space a special homely atmosphere. In addition to the breath of the past, modern technology is also present here, because solar panels are used to heat the water, which reduce electricity consumption in the summer. There is a TV set in every room, and the entire farm is covered by the Internet.

The restaurant, which is located in the house, the summer garden, and the closed glass hall are used for catering purposes. The hall is most often used for holding seminars and other gatherings, and it was built on the space where there used to be a parking lot for agricultural machinery. Culinary specialties that are most sought after by guests at this farmstead are: veal knuckles, veal perkelt, ajmokac, schnenokle, and on Sundays rinflajš, as well as other Vojvodina specialties. The specificity is that in many dishes, instead of rice, barley is used, as a local grain, so that sataras with barley is also on offer.





4. 5. 6.

Dining room and bedrooms with antique furniture.

Source: Photo G. Mulić

There is a stable with 26 horses on the farmstead, and a riding school is also organized. The school is accessible daily, first of all, to the children, because the coach lives on the farm. Equestrian tournaments, dog shows, etc. are often organized here. Numerous tourist facilities, high-quality catering offer, as well as accommodation facilities, are responsible for the prestigious position of this farmstead on the tourist market during almost three decades of its existence.

Majkin and Cvetni Farmstead

Ethnopark "Majkin Farmstead" is about three kilometers from Palić, it covers 30 hectares and includes two farmsteads: Majkin and Cvetni. Majkin farmstead and Cvetni farmstead are owned by the Gabrić family. This family has been cultivating a special tourist product based on agricultural production for two decades. Through tourism, they successfully market the agricultural products of small producers from the surrounding area. The idea of the owner of this farmstead is to enable tourists to try the best agricultural products from the wider area in one place. The whole family, three adult children and parents, decided to stay on the farmstead and continue the tradition of their ancestors. One son graduated from the Faculty of Agriculture in Novi Sad and is in charge of the development of agriculture, while the other son successfully manages tourism.


7.


8.


9.


10.

View of the house on Majkina farmstead and on Cvetni, a farmstead, fishpond and numerous domestic animals are located on the farmsteads

Source: Photo Photo: G. Radović

Agricultural activity – Until 1998, agricultural production was mainly based on animal husbandry, but then it was redirected to fruit growing. Today, apple and plum plantations dominate, and the owners have developed vegetable and arable farming. Half of the food for the needs of tourism is produced independently. Animal husbandry is also represented on the farmstead, mango trees are grown, and every autumn the famous pig slaughterhouse – „disnotor", is organized here, which is extremely interesting for tourists.




11. 12. 13. 14.

View of the dining room, antique clay stove and original sink at „Majkin farmstead", and picture gallery at „Cvetni farmstead"

Source: Photo G. Radović

Tourist activity – Farmsteads are categorized and have the First category of service quality. „Cvetni farmstead", which is only 50 meters away from „Majkin farmstead", was built for the purpose of tourism and within it there are accommodation facilities. The farmstead has 15 comfortable rooms, each of which is air-conditioned and has a bathroom. At „Cvetni farmstead" there is also a dining room for breakfast, a reception, a TV room, a meeting room, a sauna, a mini gym, and a swimming pool. Art colonies are also organized here, so there is also a gallery with about 300 paintings, and workshops of old crafts are also organized. There is also a mini stable at „Cvetni farmstead", where guests can ride horses, ride a horse-drawn carriage or sleigh, and the youngest can ride ponies. Within the ethno park there is also a children's playground, a golf, volleyball and mini-soccer field, as well as a souvenir shop.

On „Majkin farmstead" there is a restaurant of local cuisine, which can accommodate up to 500 people. The specialties of the house are apple wine and apple ajvar. There is a fishpond on „Majkin farmstead" which is only used for sport fishing, which means that all fish caught must be returned. Capital specimens of carp, grass carp, catfish, perch, crucian carp and pike are raised here. On „Majkin farmstead" there is also a typical country yard with geese, ducks, turkeys and poultry.

In „Majkin farmstead" and „Cvetni farmstead" a good connection between agriculture and tourism was achieved, and numerous high-quality tourist facilities were developed. The local cuisine restaurant offers dishes according to the owner's grandmother's recipe, i.e. dishes that represent the tradition in the gastronomy of this farmstead and area.

Dida Hornjakov Farmstead

Dida Hornjak's farmstead is three kilometers from Sombor. The farmhouse was built in 1901, and has been owned by the Hornjak family since 1929. The touristic name of this farmstead is in memory of the owner's grandfather, or "dida" as Bunjevci say, who bought this farmstead and left it to his descendants as an inheritance. Thanks to the owner's love for the traditional farming way of life, persistence and continuous financial investments in the restoration of the farmstead, today the farmstead has kept its original appearance, but at the same time it can offer guests modern comfort. Today, almost all groups of tourists who visit the cultural and historical sights of Sombor come to this farmstead to get to know the former way of life and work on it. According to the owners, their wish was to preserve the history and culture of the farming lifestyle for themselves, but also to show it to tourists. They succeeded in this because, in more than two decades, as long as they have been engaged in tourism, they have hosted tourists from all five continents.

Agricultural activity – The main activity on the farmstead was agriculture, and since 2010, the owners have decided to engage in tourism as well. Today, the agricultural activity is a platform for tourism, both in terms of supplying the necessary foodstuffs, and in terms of financing, because they cannot yet earn enough funds from tourism as is necessary for the continuous restoration of farmsteads. The Hornjak family cultivates about 100 hectares of land, of which 10 hectares are in the immediate vicinity of the farmstead. They are engaged in agriculture, cattle breeding, and raise sheep, pigs, ducks, geese, turkeys and numerous poultry on the farmstead. Vegetable growing is a function of the required amount of products for tourist activity.


15.


16.


17.


18.

Designation of the category of tourist services, the view of the house from the street, the gonk and the economic courtyard

Source: Photo Photo: G. Radović

Tourist activity – Farmstead is categorized and has the First category of service quality. The farmhouse has accommodation capacity of five beds, i.e. two rooms, which have separate bathrooms. The owners do not plan to increase the accommodation capacity, as this would damage the authenticity of the farmstead. Central heating has been introduced, and the boiler is heated by soybean straw. The tourist season on the farmstead lasts throughout the year, but each visit must be announced in advance. Guests are provided services on a full board basis, and the price includes everything that is offered outside of regular meals (fresh fruit, homemade brandy, juices,...). The hostess prepares the food herself, the traditional food of this area is on offer: pork soup, rinfleish, sauces, fashir, stuffed duck, fried chicken, as well as poppy seed or cherry strudel, ...

19 20 21 22

Dining room, accommodation facilities, ethnic setting in the dining room and in the museum

Source: Photo G. Radović

In the restaurant, in addition to enjoying the food, tourists can also stay in an interior enriched with an ethnic setting, including two dolls dressed in a festive Bunjevac costume. Guests can also see the many animals that are on the farmstead, but also visit the souvenir shop or get involved in the work of the workshop of old crafts. In addition to woodcarving, painting of old pepper tiles is also taught here, as well as bottle making, tinkering, a craft that has almost disappeared in the villages of Vojvodina. Tourists can also learn how to embroider, and the hostess wants to get a small weaving loom. Pre-school children from Sombor and its surroundings also learn the techniques of traditional crafts here, which represents the special educational value of this farmstead.

The quality tourist offer of Dido Hornjak's farmstead, the love and dedication of the hosts to their work and to each guest, which is especially important in rural tourism, are responsible for the fact that this tourist facility has had a prestigious position on the tourist market of Vojvodina and Serbia for more than two decades.

Conclusion

Farmstead tourism is a form of rural tourism that has been successfully developing in the area of AP Vojvodina since the 90s of the 20th century. Today, it is the Vojvodina rural tourism product that has the highest demand on the market. The paper presents three farmsteads with the longest tradition in tourism. On the farmsteads, whose offer was the subject of analysis in this paper, tourism develops on the platform and in parallel with agricultural production. We believe that the reason for the increasing demand of modern tourists for this form of tourism is the peace they find there, as well as numerous interesting tourist facilities, but, above all, high-quality and authentic local food, which is mostly prepared from ingredients produced on the farmstead itself or in close surroundings.

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TRIANGULAR CROSS-BORDER INTER-REGIONAL COOPERATION IN MAČVA AND SREM DISTRICTS, BIJELJINA CITY AND VUKOVAR-SRIJEM COUNTY

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Abstract

The particular aim of this paper is to draw attention to the development of cross-border cooperation as a key potentiality of successful regional and rural management in researched border areas of Serbia (RS), Bosnia and Herzegovina (BIH) and Croatia (HR). The focus is on adjacent Srem and Mačva districts, the City of Bijeljina and the Vukovar-Srijem County. This approach is singularly pronounced within the European Union (EU) Funding Mechanism of Preaccession Assistance (IPA III). The developed triangular model, with significant inter-regional and inter-rural potential reveals radically new concepts for improved cross-border cooperation in EU accession and development of one large region. Presented regional potential relates to territory, population and number of business entities. We shall suggest further possible strategy and policy developments in the interpretation of inter-regional cooperation. The model elaborated here may accelerate EU accession of RS and BIH and resolve some developmental difficulties in four regions of three countries.

Key words: Inter-regional, cooperation, triangle, cross-border model, SME potential.

Introduction

Many authors in the region have researched the system of entrepreneurship and enterprise development as a potential. Perhaps the oldest regional book on trade and merchant skills dates to 1458 (Kotruljević, 2005). And while Cappellano and Makkonen stressed the wider issue of management of cross-border regional-rural entrepreneurship (2020) no work has more complexly covered the categories of the triangular rural-regional cross border development in regions of former Yugoslavia. Such a concept is being modeled in this paper. When studying and financing models for rural small and medium sized enterprises (SMEs), the most important international development organizations strongly criticize the unpredictable consequences of spontaneous and unplanned development of entrepreneurship, and emphasize the inevitability of coordinated development of rural SMEs, (IFAD, 2023; World Bank, 1990). One comparative regional paper particularly emphasizes the potential place of SMEs in the sustainable agricultural and rural development. Considering the character of the transition process and imbalances in countries with a high share of agriculture and small peasant holdings, the authors of that work similarly point out that during 1998 all Baltic countries intensified activities for co-financing the development of rural SMEs, and that Latvia allocated as much as 43% of the agricultural budget to increase productivity, diversify income, develop rural tourism and SME credit guarantees (Nikolić and Popović, 2004). This is clearly analogous to international institutions (IFAD, 2023; World Bank, 1990). The cross-border cooperation initiatives between Serbia (RS), Bosnia and Herzegovina (BIH) and Croatia (HR) can presently be implemented triangularly under the auspices of the EU 2021-2027 IPA III funding mechanism[1]. Another option is perhaps through various national and regional projects with a prospect to promoting inter-regional and inter-rural cooperation, fostering integration with EU and promoting socio-economic development through common national, regional, local and initiatives.

Methodology

It has been demonstrated both experimentally and theoretically that inter-regional analysis involving activity and flow analysis, input-output methods and linear programming allows integration of both inward and outward potentials (Isard, 1960). This analysis has recently been further upgraded through subsequent practical application of the theory internationally (OECD, World Bank, 2007; World Bank, 1990) and in both EU (European Commission, 2023) and US (Cappellano & Makkonen, 2020). Hence, in the management of inter-regional-rural entrepreneurship in RS, BIH and HR, some new complementary hypotheses are herewith proposed in the form of systemic methodological procedures of integral scientific knowledge. With great complexity and variability of social and economic phenomena that affect both inward and outward development of researched four interconnected cross-border areas, scientific hypotheses will not be statistically tested presently but instead working hypotheses imitate (Tarde, 1903) modeled triangular economic development. Results of this model exist in the Texas Triangle mega region from Cascadia Vision 2050 (Cascadia Innovation Corridor, 2020) and in the Gdansk-Gdynia-Sopot Tri City (Palmowski and Fedoro, 2019). Starting from the defined problem in the triangular management of rural entrepreneurship, the main working hypothesis is the assumption that it is possible to accelerate cross-border development and triangularly solve the problem of rural entrepreneurship management in four regions simultaneously by applying new knowledge and achievements. Undoubtedly in this case EU accession of RS and BIH would be accelerated because cross-border regional development is a core EU principle. HR would clearly benefit. Proposed are auxiliary hypotheses as potentialities for future scientific research, as follows:

[1] In the future a rich agenda lies ahead of Interreg A which supports cooperation between NUTS III regions from at least two EU member states being directly on the borders or adjacent to them aiming at developing innovation, transport, environment, HR and other sectors.

- General recommendations for changes in inter-regional-rural entrepreneurship can be made;
- A triangular model of inter-regional rural development and entrepreneurship can be designed;
- It is possible to measure the diffusion of financial innovations, determine the cross-border index[2] of rural development based on planning and financing of four cross-border areas;
- By analyzing rural development in the past and present, the potential contribution of SMEs in the four cross-border regions and directions of their development can be further assessed;
- A cross-border financing model with regional capital and an increased knowledge is feasible;
- It is possible to see earlier mistakes in the models of inter-rural-regional development in 4 regions that prevent border SMEs from engaging in economic and technological development[3];

Designing the scope of know-how of border SMEs for faster triangular development is feasible.

In the units that follow, developed is a logical form for practical applications. Firstly, applied is the problem of triangular management of entrepreneurship (A) with a focus on cross-border cooperation (B) and regional-rural development (C) which is symbolically represented (B→A i C→A) where phenomena B and C represent the cause of phenomenon A. The goal is to simultaneously demonstrate the possibilities of efficiently developed SMEs in the function of cross-border rural development in the four neighboring regions of RS, BIH and HR. The system and management models of rural entrepreneurship are then elaborately researched not as isolated events in economic development, but as a series of coordinated actions aimed at increasing the efficiency of cross-border development of three countries in ways similar to international concepts (World Bank, 1990), to the US and Canada achievements (Cascadia Innovation Corridor, 2020) and to the EU models (European Commission, 2023). In order to gain complex knowledge about the management paradigm of cross-border rural entrepreneurship, to examine the scientific and practical values of the imitated law of triangular inter-regional-rural entrepreneurship using the proposed future verification method, and to arrive at a more complete interpretation, the following flowchart will show the logical connection of discussed hypotheses in one complex series of judgments.

Organizational diagram 1 prevents interruption of logical connections and potential inconsistency among individual hypotheses of the proposed research.

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[2] In the form of an indicative number that shows the complex relationship of initially incomparable data.
[3] Deviations that arose due to deficiencies in these two key models of regulation and management of cross-border development.

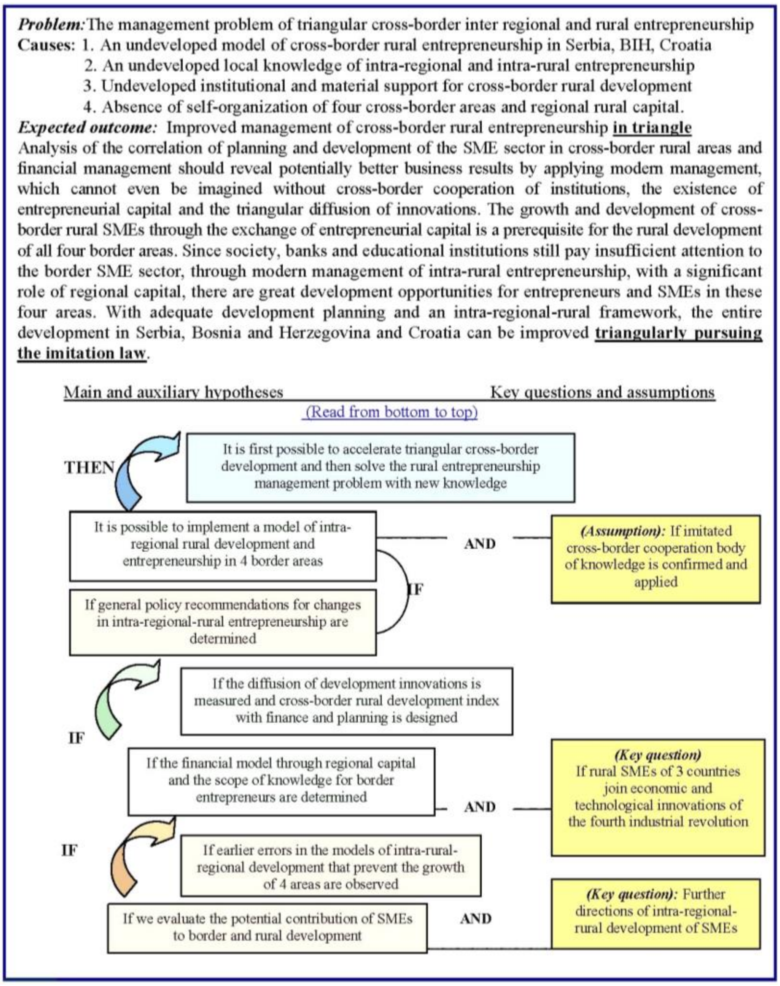

Diagram 1. Logical connection of proposed hypotheses

Source: Adapted by author based on (Vemić, 2005, p. 36)

Cross-border impact of inter-regional and inter-rural issues

National development goals cannot be optimally achieved without cross-border rural development through the support of SMEs. That is, rural poverty is reduced more easily if the economic and development strategy stimulates the development of neighboring and connected rural SMEs, which implies that the strategies and policies of SME development are aligned with the strategies and policies of cross-border cooperation. Rural, social and spatial planners are therefore expected to have a vision of connecting with neighboring and other regions (Cascadia Innovation Corridor, 2020), which should be merged with development strategies of rural regions. By explicitly proving this on the problem of demand in the transport sector, similar opinion was expressed by Božić (1984) who adopted it from Leontief's approach toward structural independence and economic development. The weaknesses and potential advantages of this aspect of cross-border development can be shown schematically and innovatively, using Venn diagrams, in two ways. First, organizational diagram 2 shows an undesirable closed state which also reveals the unattained potential of observed regions:

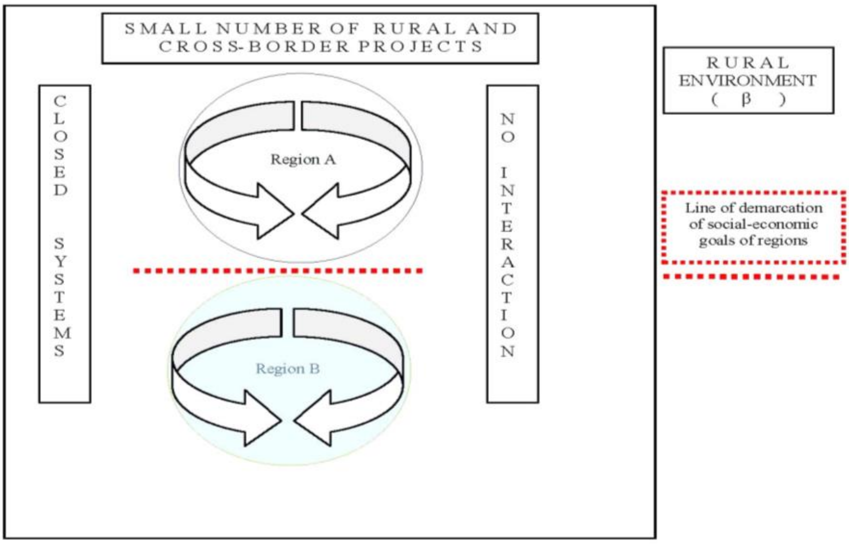

Diagram 2. View of two hypothetical closed or semi-closed rural regions

Source: Adapted by author based on (Vemić, 2005, p. 62)

On the example of two regions, note the absence of interaction between two regions which is rectified in the following diagram. Vision from organizational diagram 3, on the example of three regions, is a desirable open state, without presently discussing funding issues and modalities of cooperation:

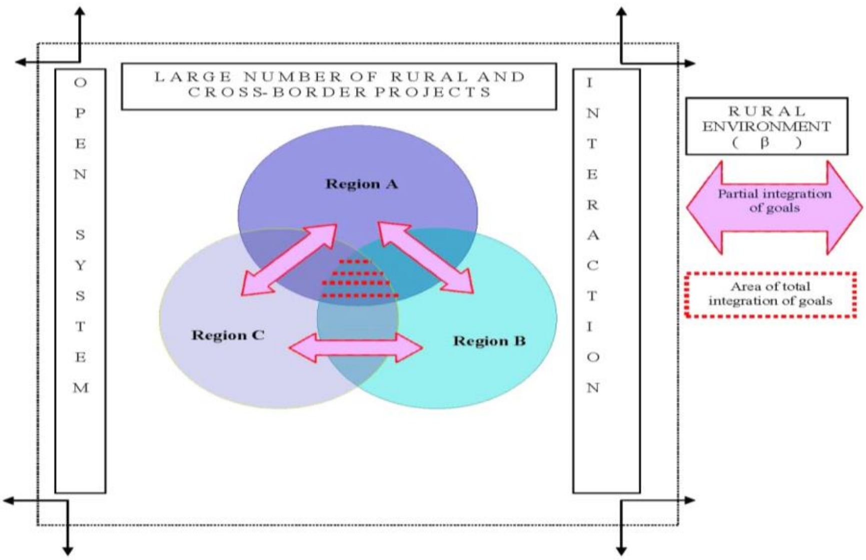

Diagram 3. View of a triangular state of three hypothetical open rural regions

Source: Adapted by author based on (Vemić, 2005, p. 63)

The author disagrees with the first scheme. It is particularistic and lacks socio-economic interaction with the external environment, while alliances of rural areas are rare, although each region has the properties of attracting and emitting material goods and migration. Special importance should be given to more diverse connections between the rural areas themselves. A region must be connected to other regional SMEs that are able to supply it with products from another sector that it has not developed in its area (North, 1955). Optimizing the social product of individual rural areas is not possible without diverse cooperation with other regions, primarily neighboring ones. That is why proposed is the second scheme mentioned above, which is based on the sociological principle of universalism and in which rural areas act synergistically as catalysts for the development of neighboring regions. Lokin (1979) specified the following issues of inter-regional cooperation: the relationship of production funds with other development factors, raw materials, personnel, communal services, compatibility of production funds and non-production activities, issues of spatial organization, organizational forms of life and work. This classification is complementary with a recent work on factors influencing cross-border cooperation in North America which specifies types of borders, political institutions, educational institutions, border security (foreign related policies), and social capital and social inclusion levels **(**Fiagbe, 2023). This implies that rural restructuring cannot be fully and successfully realized within the framework of individual regions and rural settlements. Hence, the border villages of RS, BIH and HR should be united in development with their settlements, as well as with those semi-urban settlements that represent centers in their surroundings. They can serve as a springboard for neighboring countries to develop cross-border synergy with one another (Slusarciuc, 2015). This solution may have been perhaps politically unattractive before EU accession because it was considered that one or more municipalities, regions or countries would lose their identity. This problem can be overcome through a regional approach in which participating municipalities provide different specialized services for other municipalities in the group while maintaining a separate identity (Cappellano & Makkonen, 2020). This is indeed a competitive strategy (Porter, 1980) to develop a competitive advantage for creating and sustaining superior performance (Porter, 1985) of regions (European Commission, 2023) since if all regions are the same, have the same structure, engage in the same production and are not complementary, then they will not be internationally competitive either.

In the US and in Canada even more so (Cascadia Innovation Corridor, 2020), which are decentralized states, there are examples of some of the remote sparsely populated municipalities pooling their efforts and funds for snow removal, road repair and maintenance, to purchase heavy equipment. The burden of the total debt per capita of one rural resident can thus be reduced. Within municipal boundaries, similar services can be combined to save taxpayers money. For example, the local police, fire protection, health care departments can join together for several rural areas and this can produce favorable results.

Regardless of the method of cooperation or association of rural municipalities and whether it is schools or government institutions, it is first necessary to overcome possible conflicts of districts, municipalities and regions and then to support healthy SME competition and connections. The cooperation of naturally connected cross-border rural regions should be encouraged, always keeping in mind that savings can be achieved through some agreement on cost sharing and joint provision of services for the rural population. The three researched neighboring governments and four local authorities can support this allied cooperation by providing assistance, first of all, to small businesses, associations and joint projects of several settlements. It turns out that this attitude is in line with the best practice of developed countries because the most important part of the American Rural Development Act of 1972 (U.S. Rural Development Act, 1972) emphasizes in the first chapter the attraction of business to rural areas. This chapter allows business and industrial development loans, community development loans, and development grants. These loans are administered by the so-called Farm Household Administration. When the law was passed, American legislators were motivated by the hope that it would promote development in rural communities and improve their living conditions. Also, according to Article VII of the US Federal Agriculture Improvement and Reform Act of 1996 (U.S. Agriculture Improvement and Reform Act, 1996), incentive funds are directed in three areas: the infrastructure of rural communities, rural communal services and the development of rural businesses and cooperatives, that is, SMEs. It seems that alliances of neighboring rural regions will function optimally if there are moderate differences in development capabilities between them. If the regions are too different they will have too little to offer each other and if they are too similar they will have too little to learn from each other. That's why suggested is herewith that the optimality of rural alliances is calculated by the degree of overlapping of the structure of their social product in RS, BIH and HR. When a mutual functional connection is established between companies and settlements, when the complex of rural development begins to function as a system and achieves stability, it will represent an integrated system of cross-border rural areas. Connections between villages will increase by increasing the number of villages included in the cross-border rural development and strategy, which will ensure greater integration of the rural development system (Sundać, 1986) in three observed countries. There is research evidence that presence of educational institutions in this approach (OECD, World Bank, 2007) squarely leads to economic inclusivity and integration of area with both GDP and population growth (Cascadia Innovation Corridor, 2020).

Development of a systemic triangular model of cross-border cooperation

The evidence presented in this section of the article is drawn from a broader theoretical and empirical investigation of the workings of cross-border cooperation in developing and transition economies carried out by the author. It included a detailed survey of literature and the established facts about territory size, unemployment, number of SMEs, other most recent identified potentialities of the four researched adjacent regions in RS, BIH and HR (Republic of Serbia National Employment Service, 2023; Ministarstvo ekonomije Republike Srbije, 2022; Vlada Republika Srpske, 2022; Vukovarsko-srijemska Županija, 2022).

Cross-border region profile

Illustration in organizational diagram 4 reveals the geographical position and direct proximity of Srem and Mačva districts (RS), the City of Bijeljina of Republika Srpska (BIH) and Vukovar-Srijem County (HR).

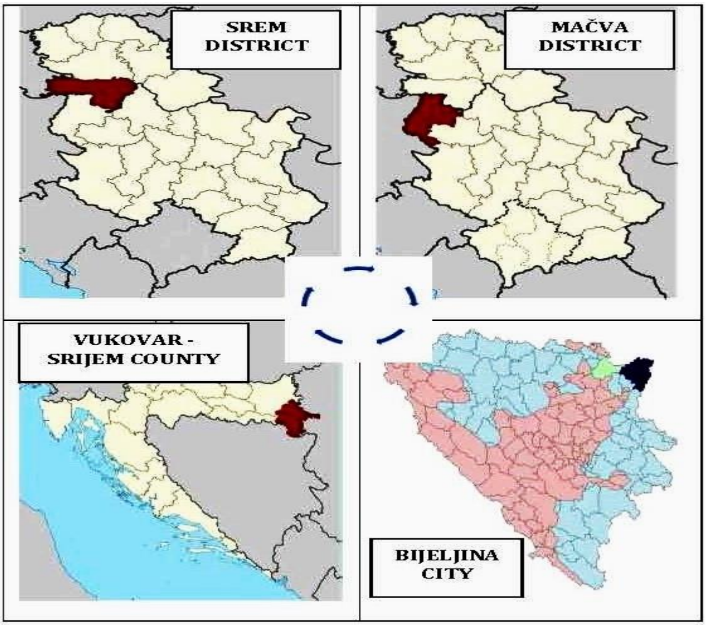

Diagram 4. Presentation of proximity of four cross border regions

Source: Developed by the author

Note in diagram 4 the similarity and difference by which Srem district and Bijeljina city both border three other regions while Vukovar-Srijem county and Mačva district each border two other regions.

Research findings

The researched area is located in the central and southern part of the Balkan Peninsula, comprising the northern and western part of Serbia with Mačva and Srem Districts, the north-eastern part of BIH with the North-East Region of city of Bijeljina and the Vukovar Srijem County of eastern Croatia. The whole area covers 12,540 km2 with approximately 800,077 people, residing in 15 municipalities of two Serbian districts, City of Bijeljina (68 settlements comprising 13 urban and 55 rural communities), Republika Srpska, BIH and 5 cities and 26 Croatian municipalities of the Vukovar-Srijem County. In terms of socio-economic development there are great similarities within the targeted area as it comprises the intensive complementary agro-business companies and significant rural areas of the three countries, as well as parts of developed industry in some Serbian and Croat areas. Despite the relative regional wealth, official high unemployment (Mačva district 16,258, Srem district 8,752, Bijeljina city 7,654 and Vukovar-Srijem County 7,606) coupled with suboptimal level of economic activity still presents major challenges of social exclusion for disadvantaged groups (with elderly, women, Roma, youth in peripheral rural areas, people with disabilities) at risk of poverty and deprivation in all four border regions. Hence, cross-border links for 39,516 SMEs are designed in organizational diagram 5.

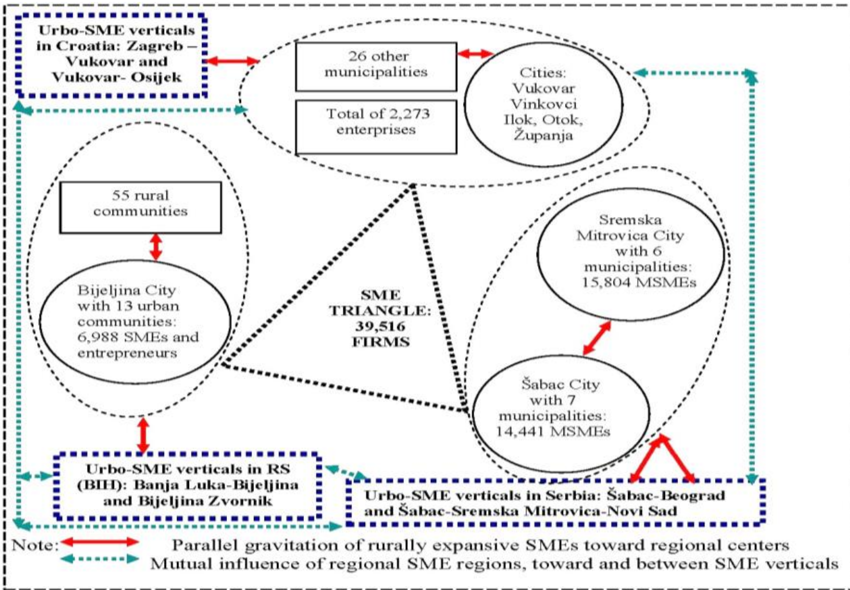

Diagram 5. Presentation of regional agglomeration with gravitational-functional SME connections

Source: Developed by the author based on (Ministarstvo ekonomije Republike Srbije, 2022, p. 96; Republika Srpska, Vlada, 2022, p. 11; Vukovarsko-srijemska Županija, 2022, p. 33; Vemić, 2005, p. 205, 203)

On the basis of the previously presented theoretical views on rural development and the methodological approach, derived organizational diagram 5 was created, which shows an illustration of the agglomeration[4] and gravitational functional connection of rural entrepreneurs and SMEs of four border regions. To determine them, the existing layout, size and rural-functional development of the rural-financial infrastructure were taken into account, then the distribution of the population, economic and other capacities in the centers of rural communities, in peripheral rural communities, as well as the logical connection, interdependence and complementarities between these communities. However, it should be noted that only narrowly focused data relevant to the hypotheses of exploratory research were available for the evaluation of the territorial intensity of entrepreneurship. For example, for some rural communities there was not enough data on the market orientation of entrepreneurs. If more data of this type is collected to determine the territorial scope of rural entrepreneurship in RS, BIH and HR, it is most likely that

[4] The word is of Latin origin: agglomerare means gathering or agglomeration and implies urban industrial agglomeration.

there will be some correction of the boundaries of the gravitational-functional connections from the diagram.

It should also be emphasized that these gravitational links of entrepreneurship change over time because they result from trade and investment of rural entrepreneurs from all parts of the four border regions and their rural communities. If certain changes arise in the functional capacities of the centers of rural communities and the overall rural areas reflecting the demographic and economic composition of the entire regions, the existing observed state of functional balance of rural entrepreneurship in the regions herewith investigated will necessarily change. Clearly from the diagram smaller rural municipalities and their entrepreneurs gravitate towards regional centers and wider urban settlements of Belgrade[5], Novi Sad, Zagreb and Banja Luka. This phenomenon is the result of the number, scope and structure of city functions, as well as the existence of veterinary and expert-advisory services, which is especially important for rural farmers to access various support functions.

It is also noticeable that SMEs from Šabac and Sremska Mitrovica gravitate towards Belgrade as a national pole of growth[6] and towards Novi Sad as a regional pole of growth while the mutual gravity of these cities is somewhat weaker. Both Tarde (1903) and Janić (1975) explained that large cities generate progress in regional development and politics. Although they do not mention small businesses explicitly, they emphasize that investments in cities, which are poles of growth, can generate greater effects for the growth of less developed areas: e.g., a role for Belgrade, Zagreb and Banja Luka. However, from the point of view of financing rural entrepreneurship and SMEs, the quality of these functional relationships is debatable. Although the existing network of financial and development institutions is most developed in Belgrade[7], district centers and wider urban settlements of Mačva and Srem districts, it is characteristic for rural areas that they direct raw materials and products of suburban agriculture to cities, while their ability to attract development capital is limited. This can be clearly seen in HR and Republika Srpska (BIH). If in a typical rural municipality there are 1-2 banks

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[5] According to the Spatial Plan of the Republic of Serbia, for example, Belgrade and Novi Sad are two among six centers of macro regions, with Kragujevac, Priština, Niš and Užice. Similar is Zagreb in Croatia and Banja Luka in the Republic of Srpska.

[6] According to Annual SME Report for 2020 of the Ministry of economy, SMEs from the Belgrade region (with a share of 33.2% in the total number of SMEs, 34.5% in employment, 45.3 % in turnover and 44.9% in GDP of the SME sector) continue to dominate compared to SMEs from the Region of Vojvodina, the Region of Šumadija and Western Serbia and the Region of Southern and Eastern Serbia, which certainly conditions regional trade flows, deepens the backwardness of rural areas and influences cross-border potentialities.

[7] Which in the absence of development of rural entrepreneurship is not only a chance for further development of the capital city, but also a distinct danger of additional redirection of credit potential towards urban centers. Unfortunately, this is a result of the different relative role assigned to typical rural areas compared to urban areas of the researched region.

with high interest rates[8], some development fund or bank does not place a single loan and there is no entrepreneurial capital or rural agency, then this confirms our initial hypothesis that rural entrepreneurship is not planned and financed. Therefore, a convergent effect of urban areas is implied in conjunction with divergent trends which deny planning, development and financial support to rural areas. Entrepreneurship is directed towards better infrastructural and financial conditions that exist in larger urban areas, which confirms the auxiliary hypothesis that there is a causal relationship between planning and financing on the one hand and rural entrepreneurship on the other. Efforts should be made not only to differentiate the four border regions of RS, BIH and HR as relatively different, but also to connect their SMEs with important lines of infrastructure outside their regions, including the identified national urban centers. There are indications that instead of pronounced concentration of entrepreneurial infrastructure in urban areas, the relative independence and mutual connections of cross-border SMEs could follow (due to the geographical location but also the relatively larger number of entrepreneurial businesses and agribusiness farms in some municipalities). This reveals some entrepreneurial tradition and major regional potential stemming from area, population and as many as 39,516 SMEs (6.78% of all SMEs in RS, BIH and HR). When it comes to potential development of rural entrepreneurship, projects on processing agriculture, opening of cold stores and various other processing facilities in the rural countryside and beyond are visible and reduce unemployment issues.

Strategic points of new cross-border rural development policy

Our previous presentations indicate that the realization of the rural development strategy and policy is a time-consuming process that can be long and painful in conditions of cross-border transition of former Yugoslavia. At the same time, the specificities of the elements of the spatial structure in certain regions, as well as the potential importance of SMEs in them, will determine the speed of movement from a closed to an open cooperative cross-border rural region. This process, like any other development process, by definition contains errors, omissions as well as learning from them, which implies that the process is cyclical, which is illustrated in organizational diagram 6:

[8] For example, the 26 municipalities of the Vukovar-Srijem County which did not grow to the status of cities, or the remote rural settlements of the city of Bijeljina which did not become municipalities. This consequently and clearly reveals the need for development of more viable municipalities in Bijeljina city and more cross-border region cities in all three countries.

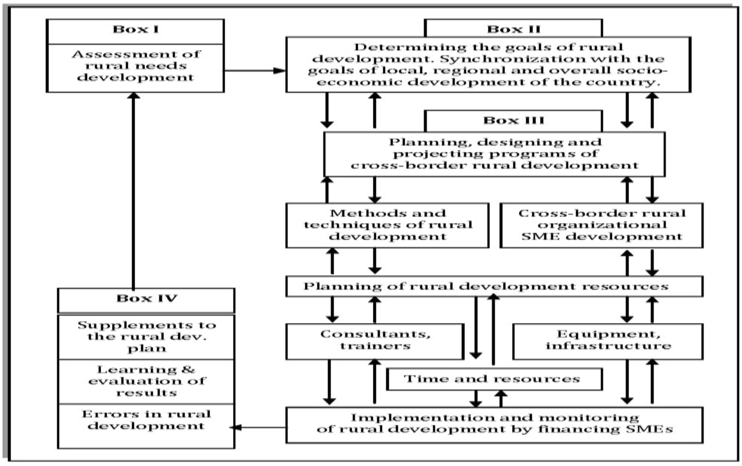

Diagram 6. Positive cyclicality of a rural development process

Source: Adapted by author based on (Vemić, 2005, p. 66)

Proceeding from cyclicality in diagram 6, let us now determine the strategic guidelines of the suggested new cross-border rural development policy stemming from resulting from research in this article. When formulating and grouping the model of rural development in the four neighboring regions of RS, BIH and HR with a focus on the management of rural entrepreneurship and SMEs, the author was guided first by the fact that reform of the development policy is needed and that 39,516 identified SMEs should be the main beneficiaries. The following 10 proposals are systematically drawn together:

1. Structural rural changes must be a priority goal of spatial, regional and within that framework rural development policy in all four neighboring regions. It is necessary to optimally distribute the economic resources of rural areas, which is based on the appropriate competitive strategy (Porter, 1980) of regions, cities, municipalities and settlements. In order to achieve this, a greater degree of processing of primary agricultural products, especially corn[9], financing and development of SMEs in cross-border cooperation should be promoted; This finding is indeed in good agreement with Cascadia Vision 2050 (Cascadia Innovation Corridor, 2020).
2. Forestry is a vital multifunctional rural activity (Cascadia Innovation Corridor, 2020);
3. An important prerequisite for rural transformation is the restructuring of the system of rural professional education, previously predominantly agriculturally oriented (OECD, & World Bank, 2007). Entrepreneurial

[9] This refers to the innovation process on the technological line of reproduction of milk and other dairy products: involving farming, production of concentrates in the second phase, cattle breeding in the third phase, the development of dairies and the processing industry in the fourth phase of the new cross border supply chain.

training and education, especially in rural areas, must benefit from the development of computerization, digitization and the fourth industrial revolution. Great potential exists in development in sparsely populated, peripheral rural areas;

4. Rural transformation does not simply mean support given only to non-agricultural activities. Taking into account the large share of agricultural employment in all four regions and the loss of personal income caused by the decline in industrial production, the problem of rural development cannot be solved without increasing productivity and the possibility of achieving revenues in both cross-border agriculture and non-agriculture. Rural development policy is not the same as agricultural policy, but agriculture that is competitive and friendly to the environment is a vital part of development, particularly in rural-urban linkages (World Bank, 1990);
5. Rural restructuring is more difficult to achieve within individual, isolated rural settlements and outside the EU advocated policy of cross-border regional development (European Commission, 2023). Villages should be united in development with other settlements, perhaps first with semi-urban settlements that represent centers in their immediate surroundings;
6. The three central governments and four investigated local governments should support this cooperation by providing assistance, first of all, to entrepreneurs, SMEs, associations and joint projects of several settlements according to best identified practices. Local rural authorities should have a much more important role in structural transformations than was the case before;
7. Cross-border social assistance to old people living in small and scattered settlements, must be optimized. Coversly more young people should start business because, e.g., only 1.4% of SME owners in the target Croatian region are young (Vukovarsko-srijemska županija, 2022);
8. Infrastructural development of cross-border connected rural areas aims at: improvement of access to settlements and elimination of the gap between the achieved levels of development of water supply and sewerage networks, energy networks and networks of waste disposal sites, i.e. favorable business enabling conditions (Vukovarsko-srijemska županija, 2022);
9. New regulations for cross-border planning and construction of rural areas should be applied; existing settlement and spatial plans should be adapted to the new circumstances of EU candidacy and membership which has being done in HR, but not yet fully in BIH and RS;
10. New and more modern laws are required to improve land use and environmental protection allowing optimizing newly created small-scale privatized agricultural production and non-farm activities in rural areas with educated workforce (OECD, & World Bank, 2007).

Conclusion

After several years of Covid-19 stagnation and the accompanying recession, faster economic development is expected in the coming period, with an emphasis on the European models of cross-border cooperation and regional development. This is because HR is already in the EU and BIH and RS are candidates. The above analysis considered it extremely important that the resulting model be designed in such a way as to enable exceptional adaptability to the new conditions and to triangularly include four neighboring border areas. The evidence, although not unambiguous, offers tentative support to the hypothesis that the proposed model will develop cross-border inventiveness and entrepreneurial spirit with the power of creative innovation, visualization and imagination among all stakeholders in the triangular region that directly economically connects RS and BIH as EU candidate countries and HR as an EU member country. Since it is realistic to assume that the carriers of cross-border development should be highly educated young rural entrepreneurs their knowledge and cooperation are highlighted. There is evidence that further research should identify which imitated knowhow can successfully support regional and rural development models in cross-border development of RS, BIH and HR particularly in relation to SMEs. This would seem to accelerate EU accession of RS and BIH and HR would clearly benefit. Interreg A would follow IPA. Lastly, the key question for future research remains how to effectively share this knowledge with entrepreneurs, SMEs and cross-border leaders in the researched region).

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ORGANIC PRODUCTION IN SERBIA AND VILLAGE POTENTIAL

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Abstract

Producing food in an ecologically sustainable way without the use of hormones, heavy metals, synthetic pesticides and herbicides is becoming increasingly popular. This is not surprising considering the many positive aspects of these products on human health. However, the potential of organic production is still underutilized in our country, which is also evident from the fact that this method of agricultural production in Serbia is carried out only on a minimal area. Organic production, as well as other alternative systems to conventional ones, such as agroecology, is a promising way for agri-food systems to guarantee availability and access to this food and, at the same time, preserve the natural resources they depend on to sustain themselves.

The aim of the research in this paper is to include an analysis of organic production, with a special focus on rural development and potential in Serbia in relation to organic production.

Key word: Organic agriculture, rural development, village, Serbia.

Introduction

Agriculture plays a very important role in the development of modern society, where the present and the future are precisely dependent on the relationship to food production. The moment when collecting agricultural production stopped and stationary production began is considered one of the most important turning points in the history of civilization and it influenced the development of various activities in society. Industrialization influenced the intensification and expansion of agriculture, which is based on economic principles and advanced procedures of a technological nature, and all of this inevitably led to conditions that increased the number of people on the planet. The consequences of that were to ensure a safe source of food, which further led to the development of other human activities. Nevertheless, the great benefits created on the basis of technological progress are what today affect the sustainability of the agricultural system globally.

Today, organic production is developed not according to the principles of ecology, and it is at the same time an economical production that contributes to the preservation of agro-ecosystems and ecosystems. It implies that quality, health-safe, controlled and certified food is produced to meet the demands of modern consumers, and at the same time it influences the rational use of resources and the preservation of the environment. This branch of agriculture, globally, is developing quite quickly and is consequently linked to responding to environmental degradation and ensuring consumer needs in terms of quality and safe food. The Republic of Serbia, without a doubt, has great potential in rural areas to organize the development of organic production and thereby influence the creation of food that is organic, high-quality, safe and thus achieve ecological and economic profit while preserving the environment. This kind of production refers to a controlled type of production from planting to the consumption of food itself, which is a preventive action so as not to damage the ecosystem and human health (Lazic, B., Babovic, J., 2008).

For a farmer, there are several motivations that can lead to switching to organic production. From the desire to sell products at better prices, to care for one's own health and the health of one's family, to increase family income, to be less dependent on external inputs, among others. The transition to pesticide-free agriculture does not depend only on the will and commitment of the rural producer. Therefore, in terms of public policies, it is necessary to include organic and agroecological agriculture in the core of the state's activities in the agriculture and nutrition agenda. Serbian agriculture contributes significantly to the country's economic development, as confirmed by data published by public agencies and other specialized institutions. However, the current demand for animal products and conventional agricultural practices, which intensively use pesticides, result in several environmental impacts, promoting the degradation of global ecosystems and bringing problems to human health. For these reasons, there is a need for a fundamental transformation in people's consumption patterns. In turn, although still shy, it is possible to see a change in the state of consciousness in the current society of productivity and consumption, and because of this there is an increasing demand for organic food worldwide. It is an activity that not only replaces the use of pesticides and chemical fertilizers with organic fertilizers, but is a new idea that aims at agricultural production in balance with nature. Serbia has significant capacities for agricultural production, and through conscious planning, it can adhere to the principles of sustainable agriculture and gain the factor of competitiveness and survival in an increasingly demanding market. In fact, there is a great potential for the expansion of organic production, located precisely in rural areas.

Organic production

Organic production and its products are very popular today. It is food that is safe and certified, with increased biological and nutritional value, high content of vitamins and minerals, and affects the promotion and improvement of biodiversity, biological cycles and activities (Ristic, L., Boskovic, N., Knezevic, M., 2018).

Organic agriculture follows the organizational principle of a largely independent business organism. This means that the organic farmer adapts land use and animal husbandry individually to the location and combines both within the farm. Cyclical processes and the circular economy determine the environmentally friendly production of high-quality food and ensure the long-term natural production bases such as soil, biodiversity, water or climate. The diversity of cultivated crops and animal species maintains and strengthens the stability and resilience of agricultural ecosystems. As a result, organic farmers provide positive environmental services for society as a whole.

The impacts of organic agriculture on the environment and climate result from binding regulations established by EU regulations, including the ban on the use of chemical-synthetic fertilizers and plant protection products, as well as the basic principles of organic agriculture. IFOAM sets standards and principles for organic agriculture at the international level (IFOAM 2019). EU regulations (including Regulation (EC) No. 834/2007, Regulation (EC) No. 889/2008) define how agricultural products and food products labeled as organic products are produced. Due to these regulations, material and energy inputs into organic agriculture are limited. In organic agriculture, the use of mineral nitrogen fertilizers is avoided. Nutrients are supplied to the soil mainly in organic form in order to increase reserves of humus and nutrients, soil fertility and feed crop plants through nutrients released by biological activity.

European regulations define organic agriculture as a "global system" based on a combination of advanced environmental protection practices, high biodiversity, protection of natural resources and the application of strict welfare criteria, capable of producing products that meet consumer demand for high quality and long-term conservation of natural production bases The main goal of organic agriculture, according to the European Union, is to define an agricultural cultivation method that respects the environment and which:

- respects natural systems and cycles, maintains and improves the health and balance of soil, water, plants and animals;
- guarantees responsible use of energy and natural resources such as water, land, biomass and air;
- meets strict requirements regarding the breeding of species-appropriate animals.

According to European regulations, organic farming must aim to produce a wide range of high-quality food using methods that are not harmful to the environment or human, plant and animal health and well-being. The use of products that are GMOs (genetically modified organisms), contain GMOs or are made from GMOs is not allowed on organic farms. No chemical fertilizers are used, but the natural fertility of the soil is maintained and increased by appropriate cultivation methods, such as crop rotation, green manure and organic fertilization. The use of chemical-synthetic products such as herbicides, pesticides, insecticides, etc. is not allowed.

In organic agriculture, industrial animal husbandry is not allowed, where animals are kept exclusively in barns. Each farm can keep only a certain number of animals, which is determined based on the available agricultural area. In order to protect the health of animals, their natural defenses are strengthened without the use of preventive drugs, except for vaccination, of course. The animals are not kept in cages or battery cages, have free access and are fed organic products. The same environmentally friendly processes aimed at general well-being are also used in product processing. The use of colors, artificial sweeteners, flavor enhancers and other additives and excipients that are not necessary for production is strictly prohibited.

The primary elements of the organic production system include (Little, 2008):

- good soil management that contributes to good fertility, maintenance of high content of organic matter, high activity of microbiological nature and good soil structure,
- a well-designed crop rotation that is essential for balancing crop nutrition, controlling weeds and minimizing disease and pest problems,
- a preventive, non-chemical approach to controlling weeds, diseases and pests,
- profitable contribution to organic cover crops and livestock.

The Republic of Serbia incorporated sustainability goals into the National Strategy for Agriculture and Rural Development (2014-2024), i.e. recognized the need to specifically encourage organic production. Advocating for the dynamization of organic agriculture is a way to encourage the competitiveness of agricultural entities, increase the volume of processing of organic raw materials, encourage exports, protect the agro-ecosystem and ensure a solid standard of living for farmers (Jankovic, 2020).

Rural development and potential

Rural development has always been a very important issue in discussions related to economic development, especially in developing countries. In those countries, the rural mass is a large part of the population. Despite the fact that a large number of residents from rural areas migrate, rural development in a large number of countries has influenced that a large number of people remain, but poverty is still recorded. The distinction between rural and urban territories is great, and a great deal of pressure has been created on the social and economic issues of a large number of developing economies. These factors, among others, tend to emphasize the importance of the development of rural areas.

Policy makers in a large number of developing countries have recognized this importance and are implementing a large number of programs and measures to achieve the goals for rural development. Certain countries achieve important results in this, but some still fail to make significant changes to the problem of rural underdevelopment. Rural development is a process where the goal is to improve the well-being and self-regulation of residents living outside urban areas through collective processes.

Table 1. Basic principles of formulating, implementing and controlling the success of the sustainable rural development strategy

Principles of strategy formulation	Principles of strategy implementation	Principles of controlling strategy success
The principle of sustainable economic development	The principle of defining goals with clear budget priorities	The principle of defining economic, ecological and social indicators for monitoring success in strategy implementation
Ecological principle - preservation and improvement of the environment	The principle of effective participation	The principle of selecting indicators based on the key determinants and success factors of the strategy
Social principle - realization of long-term benefits for marginalized social groups and reduction of poverty	The principle of connecting national and local levels	The principle of continuous monitoring of strategy success
The principle of balancing and integrating economic, ecological and social approaches, in accordance with the needs of current and future generations	Development of capacities and reliance on them	The principle of continuous comparison of achieved results and defined goals

Source: (Ristic, 2013)

Organic production and rural development in Serbia

Serbia has a long tradition in terms of policy for rural and regional development. Back in the days of the SFRY, there were marked regional disparities in the development of some republics and heterogeneity compared to natural resources in terms of production, economic and organizational parameters for agricultural production. However, this long tradition does not mean that policies are implemented in this area with clear and focused visions for development. Mechanisms for implementing the policy are related to the rural area and the territorial dichotomy in development and were insufficiently coherent, so they were not stable and long-term, and the consequence of this was the absence of the synergy effect. Limitation in terms of human resources, lack of regulatory framework, problems in financing and insufficient experience in policy formulation and management in large projects are the basic obstacles related to effective rural development policy (Jankovic, 2020).

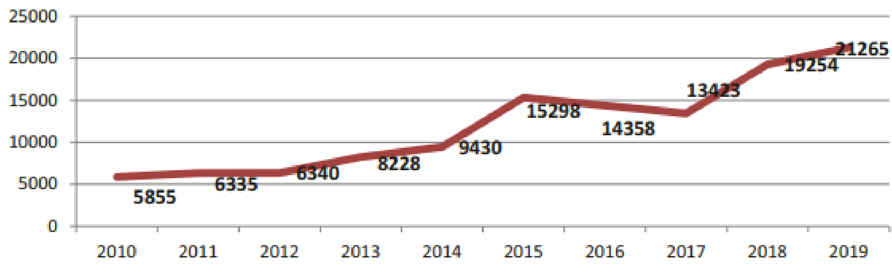
What we can see today is that Serbia does not have a strategy for sustainable agricultural production. In draft form, the Organic Production Strategy existed for a long time, but was not adopted. Measures to improve organic production are defined in the draft of the National Rural Development Program 2022-2024. which has not yet been adopted. It primarily talks about incentive measures for the development of organic production.

The territory of Serbia is characterized by favorable conditions for the development of organic agricultural production. The traditional association of people for agriculture, smaller holdings, advantages in terms of agro-ecology, banning the cultivation of GMO products, the establishment of institutions in organic production and access to larger markets, and this is a very good foundation for the development of organic agriculture in Serbia. The primary characteristics of organic production in our country are the very modest total area compared to the total agricultural land and the very modest number of crops in agriculture, that is, the crops produced. Nevertheless, organic production in Serbia is still at a much lower level of development and there is a relatively small representation of organic products, and the prices of organic inputs are higher, and this greatly affects the reduction of the previously highlighted benefits (Tomaš Simin, 2019).

The economic structure of the rural areas of the Republic of Serbia largely depends on the primary sector, especially agriculture, and is still based on the depletion of natural resources (Jankovic, Turizam i održivi ruralni razvoj, 2014).

Agriculture is still an important sector of the Serbian economy, with a significant contribution to overall economic development and social stability. Primary production from agriculture, hunting, forestry and fishing accounted for over 10% of GDP in 2009. The share of the food, beverage and tobacco industry in GDP is on average 5.5%. Agricultural exports contributed about 24% of total Serbian exports in 2009. About 43% of the total population lives in rural areas. About a third of the active population depends at least partially on agriculture for their livelihood. Rural areas suffered from intensive migration and low levels of economic diversification. They lag behind urban areas in terms of service provision and household income. Rural enterprises do not have access to affordable loans for investments and support services (Bejran S. et al., 2014).

If we look at the period of one decade, it is possible to see the trend of growth of the total areas under organic agriculture in Serbia (graph 1). During that period, the total area increased by 263%, and the cultivated area increased by almost 500%.



Graph 1. Total areas - organic agriculture for the period from 2010 to 2019

In the future, exports will be diversified into three main markets; CEFTA, the EU and the Port of Constanta. It is necessary to have a correlation between price and export, in such a way that higher export has a positive effect on the domestic price in order to increase margins (which would affect additional earnings). Increased domestic production will affect price changes and increase exports by over 50% by 2025. In the following period, the main carriers of exports should be specialized foreign trade companies that provide the most favorable conditions in foreign trade (Gajdobranski, 2022). The effectiveness of the agricultural and rural development (ARD) policy is related, among other things, to the adequacy of the policy system and the management arrangements in place.

There is a growing consensus that organic agriculture does offer certain environmental benefits that are greater than those of conventional agriculture. For example, nutritionally, while there is some evidence that "a mostly organic diet reduces the amount of toxic chemicals ingested, completely avoids GMOs, reduces the amount of food additives and dyes, and increases the amount of vitamins, antioxidants, and beneficial fatty acids, others argue that by current scientific evidence does not show that organic food is any safer or more nutritious than conventionally produced food.

Organic farming is an approach to sustainable agriculture, as it balances aspects of productivity, environmental impact, economy and social well-being better than conventional agriculture. All in all, organic agriculture with its principles can support sustainable rural development, because it seeks to preserve nature, which is in line with the definition of sustainable development in which future generations should have the same opportunities as current generations (Jankovic and Jovanovic, 2018).

The strategic documents that contribute to the management of the LEADER program in Serbia, North Macedonia and Albania, as well as other countries in the Western Balkans, are:

- agriculture and rural development strategy,
- medium term programs,
- IPARD II programs and
- strategic and/or program documents of other ministries or state bodies, a large part of which is in charge of regional development, local self-government and civil society.

And in the previous reports on policies related to agriculture in these countries, it is stated that great progress is being made in terms of harmonizing long-term strategic documents and structures of an administrative nature with EU requirements (Bogdanov et al., 2018). These countries have also developed multi-year program documents, as well as a program of pre-accession aid instruments for rural development.

As an instrument for achieving rural development, apart from politics, it is also possible to use the agreed agreement on the free movement of agricultural, food and animal products reached between Serbia, North Macedonia and Albania within the framework of the Open Balkans initiative. At the border crossings of these three countries, there is a special lane for trucks transporting agricultural products, food and animals, where controls are not carried out. All veterinary and phytosanitary certificates are mutually recognized between the member countries of the "Open Balkans". The procedure for this is simple and only requires timely information through the electronic platform for the day of truck transit. The agreement on the free movement of agricultural, food and animal products was signed on December 21 at the summit of the Open Balkans initiative in Tirana. Mutual recognition of work permits and electronic signatures of citizens and companies was also agreed upon at the meeting.

Conclusion

Any form of land management is an intervention in nature. In organic agriculture, management should be carried out in such a way as to use and improve the natural interrelationships of the ecosystem. In order to increase yield and quality, natural processes that form the basis of agricultural production are stimulated.

Stimulating the system in this way is successful in the long term only if it follows the example of nature and functions in the balance of natural processes. With organic farming, natural resources in ecosystems are used but conserved. Non-renewable sources of energy and raw materials are preserved, and the organic farm is understood and developed as an organism, with the aim of making the material and energy cycles as closed as possible (not closed). This means that the use of external means of production is strictly limited or completely prohibited, as is the case with synthetically produced nitrogen fertilizers, chemically synthetic pesticides and growth regulators. Agricultural activities are directed towards their consequences. This minimizes negative impacts on people working in agriculture, farm animals, soil, harvest, the environment and consumers. With this forward-looking holistic approach, organic farming lives up to its claim to be particularly compatible with people, animals, the environment and the climate.

A large area of Serbia has suitable natural resources for the development of organic production. However, such potential of agricultural resources is insufficiently used, both in conventional and organic agriculture, regardless of the fact that there is a rich tradition of farming and an increased demand for organic products globally. There are not enough educational programs in that area and system support, high certification costs are observed, problems are also related to association, and this has a negative effect on agricultural producers and processors to be oriented towards organic production.

Nevertheless, organic production is a development opportunity for Serbian agriculture. Despite the fact that the strategic importance of developing the organic sector in Serbia is often emphasized, it has not been institutionally supported and developed enough, and we can certainly see that based on development indicators, scientific and professional analysis. Organic production can play a very important role in the sustainable development of rural areas, but also in other areas, especially in the protection and improvement of the environment, preservation and rational use of natural resources in Serbia.

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SERBIAN VILLAGE IN COVID-19 CRISIS

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Abstract

At the end of the second decade of this century, the COVID-19 pandemic swept the world globally. The pandemic has taken the world by surprise, even though pandemics have occurred before with heavy loss of human life. The ways in which the pandemic crisis was handled in the 21st century in the initial stage were more or less the same as a few hundred years ago, namely: isolation, incarceration, restrictions, bans, etc. The initial period was accompanied by a large number of deaths even in highly developed countries, entire industries were banned, and the movement of families was limited to their apartments and yards. Many of the measures adopted were contrary to basic human rights, and the pandemic has largely served a number of political systems for establishing dictatorship and one's own government.

In Serbia, during the pandemic, a restrictive system of fighting the virus was introduced, which included closing borders, abolishing public transport between cities, reducing the movement of people, even the introduction of a state of emergency, i.e., curfew. Such measures applied to the territory of the whole country. However, the practical implementation of these measures was unequal, so that the population of urban areas, due to its concentration, was more under surveillance than the population in rural areas, where there was a greater dispersion of the population, but also a reduced need for movement, because the rural population was provided with their own means of subsistence from their garden, barn, orchard, pen, etc. The culture of rural population is oriented that every household has reserves in basic living needs for a certain period of time, which means at the same time less attachment to retail stores, i.e., supply from external sources.

Precise analysis shows that not all parts of individual countries have suffered equally the consequences of mass health infections. In urban areas, i.e., in large cities, the population was more difficult to bear the pandemic, because entire cities, or parts of cities were closed, or from one part of the city or country could move from one part of the city or country with special permits issued by police authorities. In this, vulnerable groups suffered the most, namely the elderly, the sick, the poor, the homeless, as well as single people, especially men who were more or less left to fend for themselves. The same applies to pets, which in the later phase of the pandemic were conditionally said "valve" for leaving apartments. It turns out that pets during the pandemic were more attentive to the population.

The previous statements also apply to the Serbian village. As in other times of crisis, the pandemic has significantly less felt the impact of the pandemic

compared to urban units. Although the measures of alleged protection against infection, even farmers were forbidden to go out into the field and cultivate their land, their gardens and perform other agricultural work, thanks to private property, residents of rural households were able to get out of their houses, move within their yard and cultivate their properties near the household. The inhabitants of the village are in solidarity by nature, people are more dependent on each other and are able to help each other, which is far more difficult in cities, especially in large harvested centers where often the neighbor does not know the neighbor, where they do not say goodbye, etc. In a word, the socialization of the inhabitants of the countryside is at a far greater level than in cities, which is especially important for living in times of crisis. People from the countryside, especially in the mountainous areas, had the opportunity to engage in livestock breeding on pastures and traditional production of dairy products, and to organize sales via the Internet, but also to be in the clean air, as a prevention of infection from the COVID-19 virus.

The pandemic in Serbia has led to an inversion of population movements. Traditionally, the population moved from the villages to the cities. During the pandemic, but also after the World Health Organization declared the end of the pandemic, the population moved from city to village. The more dispersed the villages were, as it was in the mountainous areas, the more attractive the locations were for possession or renting by the populations of the cities. The urban population left the cities, even buying houses, but also building houses in rural areas. There was an improvement in the demographic structure, as villages and rural areas were settled and highly educated. People reasoned that it was healthier to live in villages, especially in conditions of ecological pollution of large cities, and highly educated professionals, thanks to internet technology, were able to perform jobs and work tasks in the same way as from urban areas. Real estate prices in rural areas have skyrocketed, while lowering prices in large cities. This has had a positive effect on the revival of already abandoned villages, the occupation of rural areas as well as border areas, which has increased the security aspect of the country.

Thus, the village as we know it has partially lost its anatomy and functionality and smart villages are created that provide greater satisfaction to the rural population, but which also increase the influx of the city population into smart, i.e. digital villages. This ensures the sustainability of the village as one of the oldest institutes, contrary to many opinions that advanced technologies and artificial intelligence will call into question the existence of not only villages, but also cities, and even man as a reasonable and conscious living being.

The paper deals with the question of the functioning of villages in the conditions of the COVID-19 pandemic crisis with an emphasis on the Republic of Serbia, the differences between the city and the village and the perspective of the village with reference to the smart village. The aim of the paper is to point out the impact that mass health infection has had on the rural population, as well as on certain industries related to the village, such as agriculture, tourism and especially rural, hotel and agricultural development.

Key words: Village, Rural landscapes, Smart village, Rural tourism, Ecological village.

Introduction

It is well known that the Republic of Serbia is a country with predominantly rural areas and population. The basis of the functioning of the village is agriculture, and the basic resource is the land that is increasingly polluted, with a reduced labor economy, increased costs, labor shortages due to the departure of young people from the village and the fact that the village has become old with a dark perspective. Of the total area, rural areas account for less than 50%. The village, despite under-built infrastructure, is still a relatively healthy place for the population to live. It has a lower level of pollution of soil, water and air. Nature, thanks to its underdevelopment, is still preserved, which allows to drink clean, often spring water, to breathe clean air and even to grow organic, that is, food that is not contaminated with pesticides and is grown in the traditional way. This has a significant impact on the health and resilience of the rural population in relation to urban, and thus a reduced possibility of health infection.

This led to a significantly lower number of COVID-19 cases and deaths in villages than in cities. Those affected by this virus even had less intensity and shorter sick days compared to the population in cities. There were villages in Serbia that for months in the peak of the pandemic did not have a single case of patients, or existed, but the patients were not reported, but were treated "in their own direction".

From the point of view of the economy, the pandemic has produced a certain paradox between supply and demand for products and services globally, which has made it more difficult and difficult to solve socio-economic problems in the post-pandemic period. On the demand side, there is a shortage of all its elements, especially when it comes to families and households, which mainly buy groceries and other to meet the basic needs of life, as well as investments by the state. On the other hand, aggregate supply was also reduced, as many economic operators interrupted or reduced production due to measures taken by states to restrict or ban the movement of goods. It turns out that previous crises mainly produced or arose due to lack of demand, where the state with its macro-economic measures encouraged demand. In the COVID-19 pandemic, supply crisis has also arisen, with long-term consequences because business relations and supply chains were interrupted, markets were lost, and production due to reduced demand had no economic sense and justification. "The particular problem is that the shock still exists, and its intensity and length of life cannot be estimated with certainty. This also makes it difficult to assess future economic developments in individual countries, which is why they are changing from day to day, with the constant danger of a much sharper and longer recession, if there is a second wave of the pandemic, which is also the biggest unknown." (Piglet, 2020).

Advantages and disadvantages of the village as a community

The village and the city have some common, but also a number of special characteristics that should be taken into account when considering their relations, but also the place and role in the development of the country. It is important to point out that cities originated from villages through their urbanization and movement of the population from the village to the city. Villages are the source of the city's population, with cities gaining more and more importance, while villages are marginalized and as such lagging behind. The great concentration of the population in cities imposes the need for national governments to pay more attention to cities, because discontent, or problems that exist in large cities, can call into question their survival. In other words, one and the same problem that arises in large cities and villages, or more villages, will be treated differently and will be reacted to differently by the authorities.

The village and the city can be viewed from the point of view of the political system, i.e., administrative division, so that the city is considered a populated place that has 50,000 inhabitants and which includes several municipalities, and municipalities make up several local communities, i.e., villages. The city and the village can also be viewed from a sociological point of view, because the village is predominantly inhabited by agricultural population engaged in agriculture, cattle breeding, fruit growing, vegetable growing, etc.

The city refers to a large urban area with a high population density with city infrastructure, but also as the seats of financial, cultural, sports and other events for a particular area.

The village refers to a smaller community, usually from 100 to 5,000 inhabitants located in a rural area and engaged mainly in agriculture, and to a lesser extent to service activities such as rural tourism, hospitality, crafts. However, it should be borne in mind that cities can also be more or less rural, especially if they develop around large farms, goods and agricultural complexes. Examples of Vojvodina cities confirm this, because they were created thanks to agriculture and today partly remain rural-urban.

The differences between the village and the city in Serbia also relate to the management of the same. Cities are usually governed by mayors who have their own city infrastructure, but also republic-backed infrastructure such as police departments or stations, educated institutions, health systems, diplomatic and other representations to banking and financial institutions. Some cities, such as Belgrade, have a special status because of the importance and impact on the entire country.[1]

The problem with villages in Serbia is that many villages are disappearing, with estimates that this trend will continue. This is indicated by numerous data and research. It is estimated that in Serbia about 200,000 rural houses have been abandoned, i.e. They do not live in them, and they are equally prone to decay and

[1]"Difference Between Village and City" https://blog-examarly.comu.

collapse. Of the 4,700 villages in Serbia, about 25% are in the phase of disappearance, because they have less than 50 inhabitants, mostly old, sick and unable for any activity. Many villages do not have roads, sources of healthy and drinking water (villages in Vojvodina), do not have basic infrastructure that provides them, but also make life easier, such as: clinics, schools, retail facilities, cultural centers, etc. (Sinadinović, 2022)

Italy and other European countries see great potential in the villages, especially when the capacities of cities do not provide a normal or quality life and work. The COVID-induced pandemic has accelerated the process of village reconstruction, left central parts of cities and moved to suburbs, or rural-type mountain settlements. With the development and improvement of Internet technology and its presence in villages, conditions are created for living and working in villages to be not only healthier, but also more cost-effective. Residents in the big cities of Italy, Greece and other countries lease apartments in cities and retreat to the suburbs, especially when it comes to pensioners, single people and those who have large apartments whose costs they cannot bear.

Rural areas and villages have their strengths and weaknesses, seen from a macro point of view, but also when it comes to urban areas.

The advantages of rural areas and villages are:

- Large areas of agricultural land that has not been exploited or exploited with low-productive crops and crops, as well as relatively high soil quality, i.e. climatic conditions for agricultural production;
- Low labor cost and relatively low price of inputs in agricultural production and processing of agricultural products
- There are great opportunities and opportunities in creating new products and services that are not even minimally used and which can represent significant brands in the international market of agricultural products;
- Healthy and clean nature with attractive views of rural areas, classical villages and traditional culture, behavior and behavior of rural population;
- Great opportunities in establishing public-private partnerships;
- Rural areas and rural areas represent the possibility of employing a large number of workers who can perform sophisticated jobs from the village thanks to the application of information and communication technologies;
- Border villages and smaller towns can establish through border cooperation, as a bridge for bringing countries closer together and connecting into supply chains;
- The possibility of developing rural tourism based on ecology, since rural areas are less polluted;
- Production of organic food, both for households and for sale to urban populations, as well as biomass production and use of renewable energy sources;
- Greater resilience and better orientation of the rural population in times of crisis, which the COVID-19 pandemic has confirmed.

The advantages of rural and rural areas are clear and can be classified into: economic, technological, trade, environmental, etc. These advantages represent opportunities for the dynamic development of agriculture, rural areas and villages, and in order to achieve this and happen, structural changes in agriculture and rural areas in Serbia are necessary in order to achieve economic efficiency and market competitiveness.

The weaknesses of rural areas and villages of Serbia are:

- The poor population of the village, and where there is population, it is an old and mostly sick population, which is largely single, or solitary confinement incapable of any form of business;
- Land degradation, small plot size, small percentage of irrigation, disappearance, or reduction of animal husbandry;
- Unfavorable demographic trends continue to emigration of the population from rural to urban centers, unresolved social status of farmers
- Poor educated population structure, even for agricultural production and processing;
- Poor technical equipment, where the land is still cultivated in a primitive way and with poor yields, livestock are raised in the traditional way, etc.
- Insufficient promotion of rural products and rural environment as a better place to live;
- Insufficient motivation to embrace new knowledge and technologies, which is why poverty is increasing while increasing disparities between rural areas;
- Lack of rural infrastructure, such as roads, schools, ambulances, cultural centers, sports, recreational and other terrains;
- Obsolescence of applied technologies in agricultural and other industries.

From the above, it can be concluded that the Republic of Serbia has significant natural resources and a great chance to improve rural areas and villages. In order to exploit these potentials, structural changes are needed.

The impact of the COVID-19 pandemic on the countryside

The COVID-19 crisis is probably one of the biggest crises that has affected the world globally with a huge number of infections and a large number of deaths. It is mainly observed and studied from the point of view of the damage it has caused, which is logical, when we take into account the duration and consequences it left for time, but also the consequences that will arise even after it is completed. It is about impairing mental health, the occurrence and increasing depression, reducing labor productivity and increasing violence of various types.

COVID-19 has influenced in different ways in all areas of social and economic life, i.e. the countryside and the city, which is logical, because the villages in Serbia are also distinguished by natural and social parameters that affect development and sustainability, such as: size, population density, distance from cities, natural environment, educational and age structure. Villages representing the suburbs of regional centers are shown to have greater economic and demographic potential compared to villages farther away from cities. Depopulation is a general characteristic of the Serbian village, to the point that some border areas have almost lost their villages, or are inhabited by a small number of rural populations, mostly elderly and sick.

The closures and restrictions that Serbia has enacted in the state of emergency have reduced the possibility of production, but also the trade of agricultural and food products. Households, i.e., agricultural producers who harvested their crops, did not have access to markets, ties with buyers were broken due to limited movement, so many agricultural products remained on the plots unpicked and as such failed. It is not necessary to explain how much damage this has caused to agriculture, because the repayment of loans, the purchase of raw materials, protective equipment, technologies used in irrigation, etc. have been called into question. If we add to the above the outstanding financial obligations from buyers from previous years, we get a clearer picture of the situation in which rural households and agriculture and its branches found themselves.

While in cities the pandemic-related health service was available to citizens, in rural areas, especially in remote scattered villages, it was inaccessible, or rarely available. The city's hospitals were crowded, while rural residents often had to travel tens of kilometers to get tested, or provide an examination in relevant health facilities, such as Covid hospitals, or health centers that had a special covid-19 department. Although the crisis staffs made the appropriate decisions, the fact is that the pandemic was not readily welcomed, which as the final epilogue had a large number of deaths.

The village, i.e., the citizens of the village, largely do not believe in factual or provable medicine. They do not believe in the success of medicine, which is why a large number of rural citizens did not want to receive the vaccine, often justifying the cases of people who received the vaccine and eventually died, including health workers. The very disorganization of medical institutions in the initial stages, the lack of personnel and the use of prohibitions and restrictions have called into question the trust that the rural population has in healthcare.

During the pandemic, village residents relied on each other, which is not the case with city units. The singles, the sick and the poor in the village are more or less known to the rural population, so they could provide them with basic needs, including medicines, provide supply assistance, in conditions when retail stores were closed, but also markets as a traditional place where the rural population purchases and sells agricultural and other products.

The social distancing measures were worse implemented in rural areas than in urban areas. The reasons are that there is a distance between households, but also because of weaker control from authorized authorities in relation to urban centers. When it comes to households, distancing from family members was significantly less than cities, because household members find it difficult to accept social distance, since they are often accustomed to living in the community and find it difficult to stick to certain prohibitions and restrictions.

From the above clearly follows the conclusion that rural areas and villages in developed countries and in Serbia have suffered numerous negative consequences caused by the COVID-19 pandemic. Nevertheless, living and working in the villages and villages proved to be easier and more sustainable compared to the city, noting that the pandemic has contributed to the faster development of certain activities related to the village and rural areas. However, the indisputable fact that the pandemic in certain areas has positively affected the development of the village and its activities, i.e. The pandemic has changed more quickly than it would have happened in normal times. In Serbia, the pandemic has had a positive impact on rural and eco-tourism, but also on the development of villages.

Rural tourism and the COVID-19 pandemic

It is well known that tourism is a vulnerable economic branch. This statement is especially true of global crises such as wars, economic crises, but also mass health infections when most countries closed their national borders and restricted the movement of populations from region to region. In these circumstances, one of the solutions is the focus of the population on domestic tourism, and within it on rural tourism, as a significant alternative form of tourism.

The increased demand for accommodation facilities in rural areas has led to a 100% filling of accommodation capacities, but also to a rise in rental prices for rural households. The traditional season for rural tourism in normal times was from June to September, but with the advent of the pandemic, the demand for the use of rural accommodation space began from March 2020, when the measures of closure and restrictions on the movement of the population were announced and applied. This was also influenced by the closure of the hotel industry and the implementation of strict insulation measures. (Maksimović, 2020).

The pandemic, as noted, has had a significant impact on the economy and society. It has negatively affected economic and social flows, and on the other hand it has reduced greenhouse gas emissions and increased demand for real estate in rural and mountainous areas. In other words, the pandemic has brought some positive changes, which could not be achieved in a relatively short time under normal conditions. It is about remote work, more intensive application of information and other advanced technologies, flexible working hours and work from home, to the focus of the state on its natural and economic potential, because it turned out that countries that were more autarchic, that they survived more easily in the conditions of the pandemic.

Due to limited movement, the pandemic has reduced the use of motor vehicles that are major pollutants, but also pointed to the importance of rural tourism, which by all parameters during the pandemic experienced its renaissance. Many households, thanks to increased demand, have renovated or built additional accommodation capacities and introduced numerous innovations when it comes to physical activity on farms. During the pandemic, Italy, in order to revive some abandoned regions through: "the restoration and popularization of abandoned villages, included travel agencies that offer packages for visiting the ten most abandoned villages, which are called ghosts, because there is no one in them." The descendants of those who left these villages raise money for the reconstruction of old and interesting buildings, believing that life in city blocks has become not only boring, but also mentally problematic. In the villages of Italy, sports, cultural entertainment, artistic and other events are organized, and the same is supported by the production of healthy or organic food. It is the same with the restoration of medieval abandoned villages. Internet technologies have encouraged many governments to think about building and transforming old rural settlements into smart working-class villages, especially in Italy and using them for tourist purposes. (Lukić, 2022)

Similar measures have been taken by other developed countries.

The above can also be applied in the Republic of Serbia, which would be of multiple benefits for the state, but also cities that are becoming less and less a desirable place to live, i.e., the village as a phenomenon that needs to be maintained and improved. Rural tourism is a great development opportunity in Serbia. The basis of rural tourism, in addition to a healthy environment, is organic food, which is also the basis of rural tourist offer. However, it must be noted that the production of organic food in rural areas is sporadic, although there are all climatic and other conditions for this. "In order for it to be fully valorized in the tourism market, it is necessary to ensure the integral action of all stakeholders in its production and distribution**.**" (Milenković, 2018).

Rural tourism has gained particular importance during the pandemic, but also when it comes to other crises: economic, political to moral crisis, because it is shown that the village still cherishes traditional values, such as solidarity, honesty and empathy. In the village, you know who is who, i.e., who is the host and what his family is like, who is honest, and who constantly borrows to meet even his luxurious needs, who repays and who does not repay the debt, and even what kind of family tree it is. The rural population has a higher degree of empathy compared to the city, where many people do not even know each other, which is evident at every step, i.e., in good ness and joy, or when there is a danger of disturbing the village and its homogeneity on a number of issues. The proof of this is solidarity when it comes to the protection of river flows, logging, attempts to urbanize traditional rural areas, to the defense against natural and other disasters.

The pandemic, due to the closure of the economy, interrupted retail chains that have been created for decades, border closures and reduced production or turnover have negatively affected economic growth.

The pandemic has generally negatively affected the hospitality industry globally, as well as branches related to tourism, such as hotel management, air travel, travel agencies, insurance, etc. Tourism is otherwise a vulnerable economic activity, both external and internal factors, which required the use of the so-called internal reserves and the search for alternative ways to attract guests to travel. In addition to national bans, additional problems were caused by the poor economic strength of guests, because a large number of people lost their jobs, technological surpluses were declared, etc., which directly affected the reduction of the needs for tourism, recreation, sports, culture, leisure and other service activities.

In the first months of the pandemic, the number of tourists decreased by more than 50%. The state reacted with incentive measures to maintain this important economic branch, through giving to the hotel industry, catering shops and facilities, etc. Subsidies given to domestic hoteliers were returned to the budget, through taxes, residence taxes, and an increase in income from the sale of domestic agricultural craft products, etc.

However, the pandemic has particularly affected in a positive sense on rural, mountain-mountain tourism, i.e., the destinations that were the least visited in normal times, were the most visited during the pandemic. Accommodation capacities in the mountains, as well as in the villages, were filled, and compared to the previous period several times. Of course, with increased demand, accommodation prices also increased, which increased tourist traffic. Farms that had their own production, often sold products through a tourist product, and tourists were allowed to also engage in collecting hay, picking fruit, preparing winter stores, doing household chores and enjoying the rural environment.

Camping during the pandemic has also gained importance, both when it comes to registered campsites, as well as alternative camping with tents, trailers, by rivers, lakes or in mountainous areas. The use of campsites and camping was influenced by high prices in hotels on the mountains, but also by the desire of tourists for a special experience, or adventure.

The impact of the pandemic on environmental protection

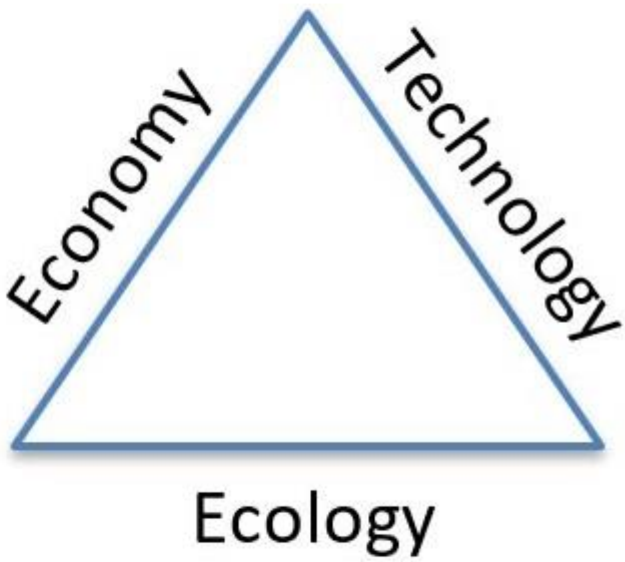
In all weather dimensions, the village faced special challenges, both because of natural conditions and disasters, or because of erroneous national policies and strategies. Nevertheless, the COVID-19 pandemic has had the greatest impact on rural, rural tourism, production and trade of agri-food products. There are beliefs that the COVID-19 virus is the result of man's irresponsible attitude towards nature, i.e. It's a natural punishment for all that man does according to nature and its elements.

At the end of the second decade of this century, the environmental issue was put on hold at the EU level. It was also believed that the European Green Deal, which was adopted in November 2019, will wait for different times for its implementation, which means delaying the implementation of the agreement on the decarbonization of Europe and the application of the circular economy as a fundamental basis for further development. However, a number of countries believed that the European Green Deal should be implemented and that its implementation could significantly affect the elimination of the consequences of the pandemic. In May 2020, the EU revised its position and adopted a new programmed on the implementation of the Green Agenda, with an allocation of €750 billion for the period 2021-2027. The goal is to establish a sustainable economic and social system, i.e. a greater degree of harmonization of society with nature, primarily through raising social awareness of the importance of healthy nature and its impact on the maintenance of public health and the economy as a whole. (Hanić, 2020)

The village gained importance with great demographic concentrations, because overpopulation in the conditions of previously designed and built city infrastructure as well as pollution, became an almost unbearable problem. With the increase in urbanization of citizenship concentration in cities. The city's population increasingly wants peace, clean air and nature with pleasant landscapes. In times of crisis, and the pandemic is one of the crises that has engulfed the world on a global scale, the village has proven to be more resilient to the challenges posed by crises.

The concept of "Eco Village" is increasingly gaining a place in regional and national development strategies. Eco village is a smart village, with organic food, where smart agricultural machines are used for land cultivation, but also cattle breeding and processing activities. The Eco village uses renewable energy sources, which means that it is less dependent on the central authorities, which are more oriented towards large cities and regional centers. Advanced villages have mini switchboards, mini factories for the production and processing of agricultural products, with one or two retail stores, services, purchase stations, etc.

The ecological village is based on three foundations, namely: ecology, technology and economics, which can be shown in the form of a pyramid.



Source: Autors

The above should be viewed in unity, which means not one, or the other, or the third, but also one and the other and the third, which is a holistic approach to this phenomenon. In other words, partial observation of individual elements does not give complete conclusions and solutions.

Ecology is the central point of the modern world, which means that environmental experts give the final assessment and acceptability of certain projects, investments, etc. As a criterion in the final assessment of the acceptability of certain investment ventures, it is taken whether and to what extent a particular venture will disturb the ecological balance of a particular area, which means that engineers propose and find technological solutions in certain investment ventures, the economic profession assesses which economic sacrifices require realization, i.e. its profitability in the short and long term. It shows that a project can be technically feasible, that it can have a clear economic justification, but if the environment is questioned, it cannot get a positive assessment. That is why environmental assessments are required, even before technical feasibility and economics. In the event that the undertaking does not meet environmental standards, it is rejected or returned for refinement, in order to reduce pollution emissions by applying the so-called "green technologies".

It is important to point out that both households and the household economy, as the basis of the village, are the source of macro, micro, international and any other economy, which means that the laws of the domestic or entrepreneurial economy can be transferred to other types of economy.

Conclusion

Although the first Neolithic settlements in the history of human civilization originated in prehistory seven thousand years ago, they have changed the least to this day, given the social and technological achievements that have occurred. It turns out that today's villages, especially in remote and underdeveloped parts of the world, are similar to those of hundreds of years ago. According to archaeological findings, Neolithic villages were created around five thousand years BC, which is confirmed by sites in Serbia, such as Lepenski vir, Vinča, etc. Many achievements from the Neolithic still exist today in other names such as pedigree or tribal assemblies as forerunners of modern parliaments, leaders of genera and tribes, tribal senate that had strong powers such as modern governments, etc. The longevity of the village as a political, demographic and economic unit shows the quality of the principles on which the village is based.

Life in the village is based on agriculture, predominantly agriculture, and the basic resource is the land as a limited resource, and the carriers of agriculture are farmers, or farmers, with agricultural machinery and technologies. In the context of the COVID-19 pandemic, the village shared the fate of the problems at the level of individual countries. It turns out that villagers were exposed to greater challenges in times of crisis than urban populations and that the burden of crises mainly fell on the villages. On the other hand, the village cherished the principles of the domestic economy, as the source of all other economies, which provided it with greater security and focus of households on the future. It turns out that a real host always thinks about times of crisis and what he will leave to his descendants. Thanks to the above principle, societies have thrived, creating over time and cities in which a large number of people are concentrated, building city culture, through the transformation of rural culture and lifestyle.

In the pandemic crisis, the village showed a greater degree of toughness and resistance to the COVID-19 virus, which was to be expected, because people in the village live in nature and use its benefits for a healthier life. The differences between the village and the city are evident, although there are rural towns or smart villages that prefer cities. This difference, due to technological achievements, is smaller, as urban centers are shown to increase the concentration of citizens, while villages are becoming smaller with the trend of dying out in the near future.

However, the pandemic that occurred at the end of the second and the beginning of the third decade of this century showed positive trends in the revival of abandoned villages and moving the city population to villages and mountainous areas, searching for a natural environment, i.e., clean air, healthy and drinking water and healthy soil for growing organic food at least for their own use. In this, the pandemic has supported the survival of villages and in the perspective, it should be expected to reduce the burden on urban centers that increasingly pose a danger to the environment and the ecological environment.

The production of organic food, the development of rural tourism, the construction of ecological, and that means smart villages, is a new trend that has found a place in the national policies of a large number of countries. The perspective of the village is not questioned, because it will be a better place for people to live in conditions of great urbanization and population concentration. Designing and constructing or reconstructing existing villages in smart villages has become *a reality*. This will also require a significant change in man's attitude towards nature, because returning man to the village will lead to concentration and increased population density that can endanger the eco-system. In this context, it is necessary to understand nature, because as Gregory Bateson says, "The main problems in the world are the results and differences between the way nature works and the way people think."

The future of the village is certain. It will survive, it will only change the way it works. Traditionally, a village that is closer to the settlements of the Neolithic era and Neolithic culture will disappear, and a smart village will be created using advanced technologies from the fourth and fifth industrial revolutions. It will become a better place to live and work compared to urban centers, especially when it comes to times of crisis, which is expected, because it has been shown that living with nature and in nature improves the psychophysical state of the population, i.e., the quality of life, and thus enables a longer life expectancy of the rural population.

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SMART VILLAGES AND THEIR FUTURE WITH REFERENCE TO SERBIA

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Abstract

More than two-thirds of the population in developed countries now live in cities. This is the result of industrialization and population movement for work, but also for a better life, less work, greater availability to educational, health, cultural and other institutions. The policies that contributed to this were oriented towards cities where industrial centers were developed, which as a rule emptied villages and rural areas and, conditionally speaking, created bad industrial workers of good farmers.

Parallel to the above, there was emigration, i.e., leaving rural areas and villages, which reduced the number of villages, but also the number of inhabitants in the remaining villages. Villages, on the other hand, have become older, making it difficult to introduce technological and other changes, as it is known that the older generation is slower to accept change and are more willing to live and work in the traditional way. Thus, the village lagged behind in relation to urban centers, with a trend of further deterioration of the situation in the villages.

Bearing in mind that there are large reserves in the villages, i.e., mountainous and rural areas, the EU has raised the issue of modernizing traditional villages, turning them into smart villages. Smart villages are parts of rural areas that use innovative solutions to maximize their own values within local government. They represent "a new concept of developing rural areas focused on digital technologies and sustainable processes", in order to strengthen the links between urban and rural areas, bearing in mind that digital technologies are not a requirement to call something smart, but they greatly help to call something smart. Smart villages are a logical continuation of smart cities, which were created at the end of the last decade of this century. They are not only reduced to smart buildings, machines, but also to smart citizens, i.e., institutions and allow you to enjoy the untouched nature and beautiful panoramas. Thanks to the application of advanced technologies, many remote villages that did not have access to conventional roads, today use cable cars, and for the supply of drones. They develop rural and ecological tourism, but also the processing of milk and dairy products in the traditional way and exhibit the same on the tables for hotel guests, but also for guests accommodated in rural households.

EU countries have adopted their national strategies covering the part related to the development of smart villages, which encourages the development of rural, island, mountain, border and other regions and areas. In order to implement smart village development strategies, it is necessary for the local population to be *digitally, i.e., information literate, in order to access public services. It should be noted that the application of information and communication technologies in rural areas is being introduced more slowly compared to other sectors. Nevertheless, in developed countries, advanced technologies in the production and processing of food are used in agriculture, there are satellite technology for collecting data on the quality of land, water, robots, drones that are able to collect a large amount of data, which is why big data analytics in agriculture has been developed. There are digital fields, farms, digital wineries, orchards, arable complexes, which radically changes agriculture, but also the local population, i.e., the village.*

Of course, smart villages also mean a sustainable environment, because advanced technologies will emit less pollution.

The paper deals with the issue of smart villages that will gain importance in the future and which will change the demographic, educational, age, but also social structure of villages. The aim of the paper is to point out the untapped opportunities of rural and rural areas, both in developed and in countries of transition, and the Republic of Serbia, which is still dominated by a classical village from the previous century.

Key words: Rural development, Smart village, Smart village in the EU, Future of villages, Smart village in Serbia.

Introduction

The first organized settlements of human groups were realized in the distant past of human civilization. Over time, they have undergone numerous changes, influenced by the development of new tools and technologies, but also intellectual maturation and increasing the mental potential of people. Caves were considered a place of residence, the original tools were clubs, or stones that were used in battle with animals. The first significant advance was made by making barns as a means for the present to serve the future. The village and the group of villages are institutes of later times, with the establishment of rules of life and work, in order to achieve greater security in common cooperation than animals, but also other tribal and family groups. In a word, villages as a community of genera or other groups were a necessity, because it turned out that man in the community more easily ensures his survival, but also growth and development.

However, precise analyses show that the village has changed more slowly compared to cities to this day, and as such lags significantly behind in relation to urban centers. Even today in the world there are villages where people live and work in a way that is in the later Neolithic, where the land is cultivated manually by humans, or using livestock, with primitive tools from hundreds of years ago. In a word, the village and its functioning are based on manual labor, where survival is ensured by the use of the strength of human muscles. The productivity of manual labor is low, i.e. In agriculture and the countryside, he barely ensures his own and the survival of his family.

At the modern level of social and economic development, the classical is disappearing, and opportunities are sought in the so-called smart village that follows the practice of smart cities, as a reaction to the situation in large cities. It turns out that villages, especially smart villages, offer great opportunities, which have largely remained unused. Namely, urbanization and the creation of large cities has led to overpopulation, a large population concentration on inadequate city infrastructure, with heavy traffic and increasing demand for housing. Cities are becoming less and less places for healthy and comfortable living, especially in times of crisis, as demonstrated by the mass health crisis that befell the world at the end of the second decade of this century.

On the other hand, the emigration of the population from rural and rural areas occurs, leaving these areas without perspective, that is, questioning their sustainability. Poor of the way of stopping, but also improving rural areas, is the construction of smart villages, which would provide the population with approximately the same way and quality of life as in cities. It is shown that the return of the population from cities to the villages can be achieved, if the quality of life in villages, i.e., in smart villages, is at least at the level of what exists in cities. The same law applies when it comes to the return of the immigration population from other countries, i.e., their return to the motherland is certain only if the living and working conditions are approximately the same as in the country where they settled. So, in order to ensure the sustainability of rural areas and villages, "the harmonization of rural and urban development is needed. Numerous projects around the world show that in rural areas it is possible to achieve such a status of facilities where carbon dioxide emissions will be equal to zero, while this is almost impossible, or with significantly aggravating conditions in urban areas." (Todorović 2019).

The processes of urbanization on a global scale are slowing down, as it has been shown that large cities and metropolises are no longer comfortable places for citizens to live. However, even in achieving the strategy of smart villages and approaching the level of smart cities, it can be dangerous for diversity and choice of places to live and work, and especially for the sustainability of organic agriculture, i.e., the production of health-safe, quality food in an ecologically sustainable way." Organic agriculture enables the achievement of ecological balance and a balanced environment in which there is a wealth of both plant and animal species, which enables organic agriculture to be a sustainable system" (Erić 2020).

The population of many countries predominantly live in cities that are uniform, without nature, although there are also "urban farms in Europe, that is, in Paris without grams of land and chemicals on the roofs of buildings, hanging pots in which tomatoes, strawberries, various salads, aromatic herbs, Swiss chard and other vegetables ripen". This was strange and surprising at first, but now it has become common place with a tendency to spread to other buildings, namely pavilions.[1]

The EU and smart villages

For a long time, rural areas and villages were neglected phenomena, especially in conditions of dynamic movement of the population from the village to the city and the creation of urban centers that were at the same time industrial centers. This led to the emigration of the rural population, especially young people, so villages in the EU have become older with increased differences in development between rural and urban areas. Gross domestic product (GDP) per capita in rural areas of the EU is 66% compared to urban areas where it was 118%. The percentage of people living at risk of poverty in rural areas in the EU was 22.4% of the population, compared to 21.3% in urban areas. The stated situation with the assessment that the trend of emigration, impoverishment and ageing of villages will continue, the EU has taken a number of measures, established funds for investments in rural areas. (Smart Village 2022).

It should be borne in mind that the criteria for assessing what is urban and what is rural have changed over time. Initially, the number of inhabitants per square kilometer was taken as a criterion. Any place that had fewer than 150 inhabitants per square kilometer was considered rural, regardless of its size. Today, the European classification takes as a criterion the number of inhabitants, i.e., "places that have less than 20% of the rural population, mixed regions where the rural population makes up 20-50% of the total population and predominantly rural regions where the rural population accounts for 50 percent or more of the total population**".** (European regional yearbook 2010).

This should also be associated with insufficiently defined what agricultural land (including population) is, and on the other hand, the insufficient consistency of data on budget incentives. which creates a high dose of subjectivity regarding the classification of measures, especially when it comes to countries whose budget incentives are not subject to external audit (they are not members of the EU, OECD, WTO as is the case with Balkan countries)" (Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014 to 2024, 2014).

The emergence of smart villages is a reaction to the emergence of smart cities. Both are in the function of a green economy and sustainable development. Smart cities and smart villages are not mutually opposed concepts, but complementary, thus erasing the classic alley between smart city and smart village and emerging a new urban-rural paradigm. Thus, "the experiences of developed countries (Austria, Germany, Hungary, Sweden, etc.) have shown that smart cities encourage the emergence of smart villages, where smart villages can contribute to the development of smart cities. Organic farms that are established in large cities confirm this. "The underground garages in Paris, which have been left empty on

[1] more about this S.F. "Ecovjesnik" Energetskiportal.rs 3.07.2020. https://energetskiportal.rs

the streets of the French capital due to the declining number of cars, have turned two young entrepreneurs into ideal places for growing organic vegetables." Produced food in the Paris underground is delivered daily at 200 kilograms of organic food to local stores. The situation is similar with the production of mushrooms in the former abandoned garage in the Chapel district, as well as in caves, i.e., abandoned parking lots, the distribution of organic products is carried out through bicycles as an ecological means of transport. (Euroactiv 2020).

There is also the opposite direction, i.e., Smart cities have an impact on the development of smart villages, especially when it comes to the use of digital services, such as e-government, smart buildings, mobile banking, e-health, distance learning, etc. It is shown that local smart villages also have a broader meaning than the local environment, just as smart farms, in addition to improving the quality of life of locals, can exhibit a global impact, although they operate at the local level. (Jovanovic 2018).

Smart Villages are not only seen as technical, but also as a philosophical, socially political, economic, cultural aspect, which provides answers to the question of how to make the village more efficient and effective, how to create new jobs, make the village a better place to live and work and stop the movement of the population from rural to urban areas, and at the same time encourage the return or migration of the population from cities to the suburbs, or in villages, i.e. rural areas that are mostly emptied, devastated with a tendency to question their sustainability. In developed EU countries, it is shown that there are rural regions where people live better than in urban areas. (Stepić 2019).

Although there is no single recipe for building smart villages, because each environment is different from the other or other environments, common to all concepts is that without broadly clarified networks, the application of Internet technologies and increased (digital) literacy of rural population, the concept of smart villages cannot be realized. In other words, there are no smart villages, without smart people and an environment in which innovation and creation will permanently emerge, primarily in agriculture and the manufacturing industry.

The Smart Villages Initiative stemmed from the policies and strategies of development of rural regions from two and a half decades ago, with the aim of uniform development of individual regions and reducing the departure of the population from the villages to the city. "In 2017, the European Parliament launched an initiative to eliminate the problem of depopulation and brain drain from European villages to European urban areas and came to life with the adoption and adoption of the EU Action Plan for Smart Villages of the European Commission", whereby smart should be understood as "designing developments based on advanced technologies and knowledge as the most important resource.[2]

[2] More about this in: Guide through European policies and sources of funding for the development of rural areas and the construction of smart villages – MK Smart Villages let's wake up Croatia", European Parliament Office, Zagreb, 2018.

The concept of smart villages is aimed at local communities and represents the core of the development of rural areas, but also of the modern economy. European Commission President Ursula von der Leyen said: "Rural areas are the fabric of our society and the heart of our economy. They are a key part of our identity and our economic potential. We will nurture and protect our rural areas and invest in their future." This also represents a basic orientation for the development of rural areas, which would make Europe stronger and more prosperous. This will also strengthen the village, as a social and economic community.

From the above, it can be concluded that developed countries have recognized the opportunity and found mechanisms to ensure the sustainability of rural areas and villages and that in future strategic policies this will occupy an important place, and that it is up to the states to look at their capabilities and create strategies that would preserve the village.

The future is in the "smart villages"

We live in turbulent and challenging times, when technological innovations have completely changed the world on a global level- In perspective, artificial intelligence, in addition to routine and executive functions, will take on numerous thought functions of man, posing a dilemma about the place and role of man in the new urban and rural conditions of life and work. The concept of smart villages was adopted by the EU back in 2019 in response to the reduction of rural depopulation and lagging relative to urban areas. In parallel with the aforementioned European funds, funds in the amount of EUR 2.4 billion have been provided for the period from 2021 to 2027 to support the development of smart villages.

The smart village "includes automation and robotization of agriculture, sharing economies such as the joint use of agricultural machinery and technologies, circular economy, digital platforms that can replace basic services (e-health, e-government...). broadband internet, use of renewable energy sources, additional activities on agricultural farms.[3]

Smart villages are also essential for more successful management of villages and rural areas in conditions of instability. It turns out that crises have become an integral part of life and work. They are increasingly common, have a more destructive effect, and integrated crises occur, combined with natural and social elements, such as: floods, earthquakes, fires, droughts to economic financial, war and moral crises. These and other crises and situations need to be adequately responded to and radically redesigned our attitude towards nature, creating sustainable, i.e., only sustainable systems. In this context, more and more elements of naturalness, i.e., natural construction, regenerative agriculture, development of

[3] More on this at: “It’s time for smart villages", Smart villages" https://ruralno.eu smart-villages, December 15, 2020).

systems for tourism, recreation, leisure and sports, etc. will be introduced in towns and villages.

The main characteristic of smart villages is innovation, which arises due to the needs and efforts to apply new technological, organizational, and other solutions in the management of rural areas, or in the management of the village. Prof. Henrique Leitao said at a meeting on innovation in agriculture in Lisbon: "If you don't feel like you have a challenge ahead of you, I'm sorry, but you won't bring anything innovative." The village is mainly a follower in the application of new technologies that have been applied in large agricultural complexes, or in other countries. The original rural innovations are incremental and refer to minor improvements in the performance of business, the introduction of digital technologies and innovative solutions and the participation of local people, in order to achieve real performance for them. The term smart is far broader than digital, bearing in mind that digitalization is not a goal, but a tool for achieving the set goals." (Oscko, 2021)

In perspective, the village will gain even greater importance for each country, because even in modern conditions it has become a better place to live, and Internet technologies have enabled the possibility of doing business from the village as well as from the city. It will not disappear under the influence of urbanization and technological innovation, but it has already undergone appropriate transformations, so there is already talk of smart villages as a future that has already begun. According to the development plans of Lower Austria, it is said that "the Energy and Environment Agency has developed a smart village project through a holistic approach for all areas of life and work", which will have a positive impact on the development of rural areas and significantly change all aspects of life and work in rural settlements. This includes housing and construction, where people will live in smart buildings on solar heating or cooling, mobility, eliminating exhaust gases, etc.[4]

The village in the third millennium will require a new approach to nature and its resources, but also a greater degree of literacy, primarily digital, so that smart devices can be used. It turns out that smart, or smart villages are in fact ecological villages that will use renewable energy sources, such as solar energy, wind energy, hydro power, etc. In some countries, movements have been formed for smart villages, in order to encourage the population of rural areas to support the transition from traditional to smart villages. There is no doubt that "smart villages" will improve the demographic renewal of rural areas, but also that they will improve the rural environment, groups of rural settlements, small towns and connections with large cities, and that it is necessary to adopt new policies and strategies of national and rural development of the country, because old policies cannot be managed by modern, i.e., smart villages. (Ristić, 2020)

Through the policy of development of rural areas, the Republic of Serbia undertakes measures for the preservation of villages, through incentives for the

[4] Smart village-the village of the future", https://fedarene.org).

return of the population from the city to the village, granting subsidies for the purchase of abandoned houses to young married couples, building infrastructure that enables the arrival to the most remote places, gasification, internet technology coverage, construction of rural infrastructure and incentives in rural events when celebrating state, religious and other holidays and festivities.

However, the village should be viewed in a broader context, i.e., in a holistic sense, connecting it with spas, mountainous hills, hotel industry and above all mini hotels, religious buildings, etc. It turns out that these are compatible elements of rural areas, because villages, as well as spas, i.e., religious buildings are mostly located in rural areas. This means that the village maintenance policy develops rural tourism, but also mountain, spa, as well as the production of organic food that is used by households for their needs, but also by selling in spas, hotels, and other rural population that is not engaged in agriculture. The village is favorable for the maintenance of old crafts through which it is partially learned about the identity of certain regions, as well as the preservation of traditions and customs that have been checked and as such proven and thanks to them it has been maintained for such a long period of time. It turns out that longevity is the best proof of the quality of the underlying settings on which something works.

It is also connected with the development of entrepreneurial spirit and entrepreneurial education, where the rural population would stay on their farms, in their farms, in their households, where they would work for themselves, and not for others and others. A modern farmer or farmer, i.e., a cattle breeder, or nomad, is not the one from the past, because there are so-called smart land-tilling machines that are entered with "white coats" and ties, so many rural jobs are cleaner than jobs in industrial complexes. (Radosavljević D et al., 2020).

The economic strength of villages is often greater than that of smaller towns. In this context, it is necessary to connect the village with wine roads, with hiking, cycling sports, to incentives in the establishment of a small business, the introduction of traditional agricultural cooperatives and purchase stations that would facilitate the village's placement of its products. Retail markets (markets) are a traditional channel, or places that should exist in every major village, or for a group of villages, because they provide some greater benefits compared to retail stores in cities in terms of freshness of groceries, but also when it comes to price competition. It is shown that markets and fairs become places where people communicate, buy and sell, and as such become places where some form of socialization of villages is carried out.

The village as a centuries-old institute, as has been repeatedly stated, must not be viewed only from a technical or economic point of view. It is much more than that, not only because of the cultivation of the traditions and values of our ancestors, but also as an environment that has a better relationship with nature, better understands natural laws and is the guardian of what nature has created. In the above consideration, it is unacceptable that, for example, the economic justification of the existence of primary schools, kindergartens in rural areas are assessed, but the broader context of this issue must be taken into account. In other words, when a school disappears in the village, the church, post office, homes of culture and entertainment disappears and the village disappears, because these institutions mark the village as a political, geographical and economic unit. Therefore, the authorities in the field of education, culture and sports should take into account the above mentioned, but also the issue of security, especially when it comes to border and villages in mountainous areas, which represent the first line of security.

From the above, it can be concluded that the village has its own perspective and that it will not disappear. What will happen, and this is partly accomplished, is its transformation into an ecological, smart and touristy place that will be a better place to live than the crowded urban violence whose citizens are forced to live on concrete and with concrete, with numerous restrictions. In times of crisis such as mass health infection, the village with its contents is a way to prevent and reduce the number of deaths.

Smart villages in Serbia

The Republic of Serbia has not followed or followed global trends in the construction of smart buildings, farms, orchards, i.e., smart cities and villages. It would be logical to develop smart cities first, which would encourage the development of smart villages, which is logical, because innovations generally move from city to village. Its essence is that "the inhabitants of the village have the same living conditions, infrastructure, developed economy, health and quality of life as the inhabitants of the city, with the aim of stopping the increasingly pronounced demographic discharge of rural areas, but also greater utilization of resources, environmental protection, as well as the application of digital technologies in agricultural practice:” (Radovic, 2018)

There are about 200,000 abandoned houses in Serbia, i.e., houses for which it is not known who owns it. The difference between a village and a city is growing in terms of gross domestic product per capita. The village is disappearing, the village is aging and getting poorer, and in times of crisis, most of the burden falls on the rural population. There are also differences when it comes to the educational structure of the population in favor of the city. One way to stop or improve rural areas and villages is to introduce smart villages, which would revitalize devastated villages. This solves the issue of increasing the economic strength of rural and urban areas, stopping the emigration of young people, but also motivates young people and their families to return, or move to the village and live, but also to do work from home, thanks to Internet technologies. The village is less dependent on the city, but the city cannot do without the village because it consumes what the rural and rural communities produce. This also applies to the culture, the domestic economy and the preservation of traditional values preserved by the village. It is shown that the domestic economy is the healthiest and that it is the basis of macro, micro and any other branch economy, and that entrepreneurial economics is a better form of resource economies than classical economics." (Radosavljević M. et al., 2020)

The Republic of Serbia adopted the Strategy of Agriculture and Rural Development for the period 2014 to 2024, based on the state of agriculture and rural areas in the period from 2004 to 2013, so that the strategy was outdated when it was adopted. It shows that in turbulent times as they are today and as they will be in perspective, it is impossible to extrapolate the future, which means that shorter periods of time must be introduced to introduce high-tech innovations. The aim of adopting this strategy is to determine the direction of transition of the agricultural sector and to activate the rural potential of these areas. The strategy also defines the amount of budget funds, in order to determine the direction of development of the new agricultural policy and rural areas. Appropriate legal frameworks were adopted, and the strategy also took into account the National Programmed for adopting the views of the European Union. (Strategy of Agriculture and Rural Development of the Republic of Serbia for the period 2014 to 2024., 2014)

The analysis of the adopted Strategy of Agriculture and Rural Development shows that it has not been largely implemented. It does not treat smart villages, which is understandable given that the Strategy was adopted in 2014 and that little attention was paid to smart villages and dedication to rural areas. It is clear that this is a long period of ten years, which is not acceptable in the conditions of dramatic technological and other changes, because in a relatively short time there have been major changes in all parts of agriculture and rural areas. The analysis shows that the deadline of the mentioned Strategy is expiring, and that little has been realized from the same, which shows that something that is strategically planned does not mean much, if it is not implemented.

The Republic of Serbia has established the Ministry of Village Care in order to create conditions and encourage those who want to settle in villages whose houses are empty, i.e., to start their own business, on agriculture, rural tourism, cooperatives, trade, agricultural products. After years of stagnation in cooperation with the Serbian Academy, this ministry has established the necessary cooperation, in order to prevent further deterioration and emptying of the village. In partnership between SANU and the Ministry, the National Team for the Revival of Villages of Serbia was formed. An important project of the Ministry is called "500 cooperatives for 500 villages", which has been largely implemented. The Ministry announces competitions for the purchase of houses and gardens for young married couples, i.e., for families, as a prerequisite for the development of smart villages, because they cannot be developed without the population. **(Gogić, 2022**)

The following four measures would also contribute to this, namely:

- Education for farmers, but also for other economic areas, especially for entrepreneurship, where each village would have a school, a mini factory, a cooperative, a purchase station, an ambulance, a religious building, etc.
- Digital connectivity in order to connect individual rural areas in a wider area with the use of digital services;
- Greater use of agrotechnology and protective equipment in agriculture in order to increase the business economy of rural areas;

- Smart rural, rural administration can provide better and faster services to citizens through the use of modern internet tools;

These measures should be applied in full, because the lack of education for farmers on a number of issues reduces the efficiency of other measures. Cooperatives, purchase stations, retail markets (green markets) are essential elements of rural infrastructure. Through cooperatives, the rural population buys and sells agricultural products, informs themselves through cooperatives about new technologies, it is possible to use the advice of experts, i.e., agronomists, veterinarians, etc. Connecting more cooperatives, often with large farms, would create synergetic effects, in the market for the purchase of agricultural machinery, protective materials, etc. The pandemic has further motivated the urban population and young people to return to the village, changing their demographic structure. In this way, young people would provide the perspective of the village over a longer period of time.

Conclusion

The Fourth and Fifth Industrial Revolutions radically changed all areas of social and economic life, on a global scale. Without the application of new or advanced technologies and the introduction of permanent technological, organizational, management and other innovations, it is impossible to be competitive on the domestic and international markets, but not to meet the growing needs of civilization. This also applies to the village, which represents a relatively small community with local capacities that are in the function of satisfying a particular segment of the market, or a particular local community.

It should be recalled that large rural areas and a large number of villages were destroyed due to the war in Ukraine, floods, earthquakes, forest fires, landslides, and that urbanization destroyed large areas of agricultural land and turned it into building or urban land, with little prospect of it returning to its original state. There is no need to explain how much this will negatively affect climate change, i.e., rural, but also national development.

A smart village is a reflection of the smart cities that emerged in the second decade of this century. Due to the increasing urbanization and overpopulation of urban or city centers, which question the comfort of life in them, but increasingly represent a bad place to live. Large city centers have experienced their maximum on a number of issues, so chances for national improvements are sought in smart villages and rural areas. However, smart cities, i.e., large urban centers are trying to use the roofs of buildings, underground garages, abandoned tunnels, caves, abandoned parking lots, etc. to produce vegetables, fruits and other agricultural products. Smart cities develop elements of rural, just as rural areas and villages develop the practice of urban centers, i.e., cities.

At the end of the last decade, the EU recognized the potential of rural areas in the development of smart agriculture, smart farms, fruit plots, arable land, etc. These countries are focused on the production of organic food, so it is close to 15 million hectares, or about 8 percent of the total agricultural land under organic food.

Austria leads with about 25%, Estonia with 21%, Sweden with about 20%. Of the former Yugoslav republics, Slovenia has 10% organic food.

Smart villages represent the future and a great opportunity for the development of rural areas, but also for the economic development of countries measured by Gross Domestic Product. The objective danger that exists is that smart villages become a copy of smart cities, which would lead to the fact that the population no longer has a choice of life (in a city or village), but will probably have to look for a place to live and work in space, that is, on another planet, which is embodied in space tourism, for which there is already a great interest, but it is very expensive and lacks space technologies that would make it possible in a mass sense. Thus, rural and ecological tourism would be replaced with cosmic, and life in smart villages with life outside of planet Earth. That is why today's villages need to be guarded against redundant digitalization and automation, that is, its traditional architecture and culture should be kept, and also make smart cities more rural.

The Republic of Serbia in its strategic documents is dedicated to the development of rural areas, while smart villages are not mentioned as "cornerstones" of this development. Smart villages in Serbia should be associated with digital-information literacy, i.e., with educated levels and the development of entrepreneurial culture, because smart villages are not made up of smart technologies, but people who manage these machines and technologies. Serbia, like other countries, should first develop smart cities and transfer their experiences to the development of smart villages. It is good that Serbia has recognized the untapped potentials of rural areas, which is why it has established a special Ministry that is dedicated to caring for the village, which, through the purchase of abandoned houses and gardens for young people, or through subsidizing the purchase of real estate, i.e., the construction of basic infrastructure, wants to regain life in the village. In this way, the direction of movement of the population from the village to the city will be reduced, i.e., it will enable the return of the population from the city to the village. In order for this to happen, it is necessary that life in the village be approximately the same as life in urban centers.

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SUSTAINABLE AGRICULTURE AND ITS INFLUENCE ON THE DEVELOPMENT OF RURAL AREAS

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Abstract

In recent decades, considerable efforts have been made to combat poverty and hunger around the world. However, hunger and malnutrition continue to threaten hundreds of millions of people. With the expected growth of the world's population until 2025, creating a sustainable food production system becomes very important to ensure sufficient resources for everyone, without endangering the planet's ecosystems. In Serbia, as in many other countries, rural development has an important place in social and economic progress. Rural areas are often affected by high rates of unemployment and poverty. Sustainable agriculture can be a solution to these problems, because it not only provides sources of income for the rural population, but also contributes to the preservation of natural resources and biodiversity. Consumer awareness of the impact of their choices is growing. Concepts such as organic farming, local food and reducing food waste are becoming increasingly important. By purchasing local products and supporting sustainable agricultural practices, consumers can directly contribute to rural development and sustainability. In the future, rural development will increasingly rely on sustainable agriculture. This includes the application of modern technologies that can help farmers better manage resources and increase productivity. Sustainable agriculture is the key to achieving sustainable rural development. Its importance is reflected in the balance between economic, social and ecological aspects. Introducing sustainable agricultural practices and supporting rural communities are important steps towards creating more prosperous and sustainable rural areas, thus ensuring a better future for all. Sustainable agriculture has enormous potential to improve rural development and ensure a sustainable future for all. Through comprehensive efforts at local, national and global levels, everyone can work together to create prosperous and sustainable rural areas that will benefit current and future generations.

The aim of this paper is to show how sustainable agriculture can influence the development of rural areas.

Key words: Sustainable agriculture, rural development, impact, village, Serbia.

Introduction

Despite the considerable efforts made in recent decades to eradicate poverty, hunger, and malnutrition, the lives of hundreds of millions of people are still at risk. By 1999, the world population had reached 6 billion, and according to projections, it will be 8.5 billion by 2025. It is therefore crucial to address the issue of sustainable food production, ensuring that food reaches those who need it most without overexploiting the Earth's ecosystems.

Sustainable agriculture is an approach to farming based on a balance between meeting current needs for food, water, and energy and preserving natural resources to ensure that future generations can also meet their food needs. This sustainable agricultural practice has a significant impact on rural development worldwide.

Over the past few decades, the agricultural sector has witnessed remarkable achievements in increasing financial returns while reducing the amount of labor required. However, it is important to note that in many cases, such practices, especially concerning the depletion of natural resources, have caused significant harm to these resources.

Current agricultural practices often lack the necessary sustainability measures. To promote sustainable agricultural and rural development, significant modifications in agricultural practices and policies are essential. These adaptations are key to establishing an environment that supports long-term sustainability in the agricultural sector.

Food and agriculture are becoming increasingly prominent in social awareness and discussion. Concepts and practices aimed at promoting sustainable agriculture and food consumption are gaining recognition. This includes concepts such as organic farming, consumer rights regarding food, local food, food waste reduction, urban agriculture, and more.

Furthermore, more and more people are becoming aware that they can be "food citizens," meaning they can influence sustainability by, for example, purchasing organic products. This awareness is growing in connection with the idea that the price we pay for food does not include all the ecological and social costs associated with food production.

Sustainable agriculture

"The ability of agriculture to consistently and sustainably supply food and various resources to the rapidly expanding global population is of great importance for the survival of humanity and, consequently, for all human activities (Velten et al., 2015). However, the agricultural sector faces numerous challenges that threaten its ability to effectively meet the growing demands of humanity, both in the short and long term.

These challenges include the harmful impacts of climate change, a high rate of biodiversity loss, soil degradation due to soil erosion, compaction, salinization, and pollution, depletion and contamination of water resources, high production costs, a decreasing number of farms, declining rural populations, and more (Rivera-Ferre et al., 2013)."

Figure 1. Sustainable agriculture

Source: https://agraryo.com/agriculture/sustainable-agriculture-methods-and-farming-practices/

Similar to the concept of sustainable development, the notion of sustainable agriculture is multifaceted in its interpretation (Culleton et al., 1994). The diverse nature of this characteristic has led to a multitude of different discourses, perspectives, or paradigms related to sustainable agriculture (Hilden et al., 2012). Consequently, both the discourse and practical application of this concept have become extremely challenging.

"Sustainable agriculture is an integrated system of plant and animal production practices having a specific application that will, over the long term: satisfy human food and fiber needs, enhance environmental quality, make the most efficient use of nonrenewable resources and on-farm resources, integrate natural biological cycles and controls, sustain the economic viability of farm operations, and enhance the quality of life for farmers and society as a whole." (Velten et al., 2015).

Sustainable agriculture is a multifaceted approach to farming that prioritizes environmental stewardship, economic sustainability, and social equity. It recognizes that the health of the planet, the well-being of rural communities, and the quality of the food we consume are interconnected. As the world faces increasing challenges related to climate change and resource scarcity, sustainable agriculture offers a path forward, one that allows us to steward the Earth for present and future generations. Embracing sustainable agricultural practices can build a more resilient and sustainable food supply system that benefits everyone.

Sustainable agriculture and its impact on the development of rural areas

Rural development has always been a very important issue in discussions related to economic development, especially in developing countries. In these countries, the rural population constitutes a significant portion of the population. Despite a large number of people from rural areas migrating, rural development in many countries has influenced many people to stay, but poverty continues to persist.

The disparity between rural and urban areas is significant, placing significant pressure on the social and economic issues of many developing economies. These factors, among others, tend to emphasize the importance of rural area development.

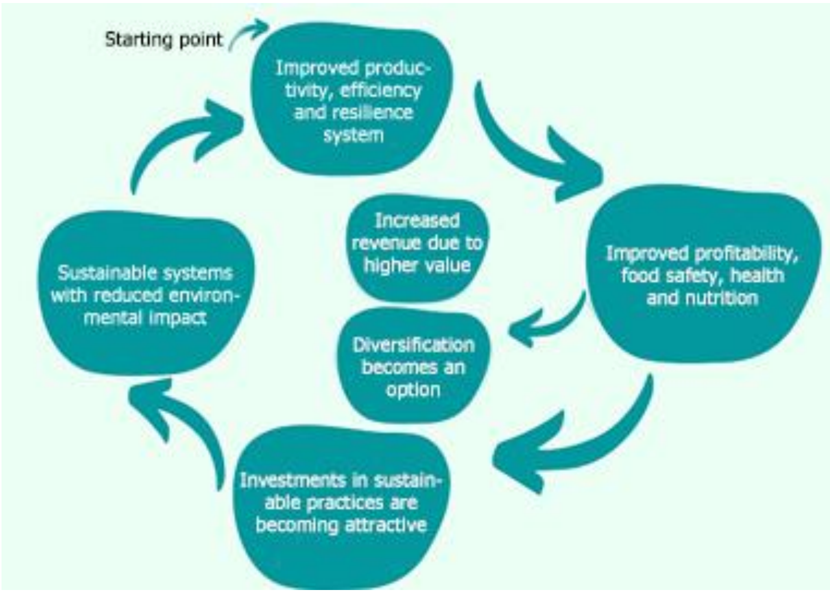

Figure 2. Increasing the productivity and value of the system is the starting point for enabling farmers to enter the circle of sustainable agricultural production

Source: https://zelenidijalog.rs/odrziva-poljoprivreda-u-ravnomernom-ruralnom-razvoju-i-zastiti-zivotne-sredine/

Rural areas, based on their characteristics, encompass natural, economic, cultural, and demographic aspects. Therefore, it is crucial to tailor development measures and policies to align with the unique potentials and limitations encountered in these regions (Ristić, 2013). These areas should be recognized as valuable resources, especially due to their significant role in food production. Thus, it's important for rural areas to have an active role in development rather than being passive subjects.

The process of educating and modernizing the rural population, which plays a significant role in agricultural changes, involves complex societal transformations in economic, social, cultural, and political spheres of society as a whole. To effectively pursue an equitable approach to rural development, with a focus on agricultural sustainability, it's essential to decentralize our development policies.

Sustainable agriculture enhances the economic prospects of rural areas. By adopting practices that improve crop yields and reduce input costs, rural farms can increase their income. Preserving natural habitats in rural areas is crucial for biodiversity, and sustainable agriculture helps maintain a balanced ecosystem. Rural communities often heavily rely on agriculture (Ristić, 2013).

By prioritizing sustainable agricultural practices, rural regions can harness their potential, create sustainable livelihoods, and secure a future for generations to come (Stojanović & Manić, 2009). Sustainable agriculture benefits not only rural areas but also contributes to a more sustainable and resilient global food system.

The significance of agricultural and rural sustainability lies in its exceptional complexity and wide applicability, covering various aspects at different levels, from small farms to global scales (Đokić, 2019). At the national and global levels, the sustainability of agricultural land can be influenced by various external factors.

Political decisions and actions at the national and local levels have a significant impact on the behavior of rural farms and the overall conditions in rural areas. Similarly, international dynamics and markets can have far-reaching consequences, especially in countries dependent on agricultural exports.

The sustainability of agriculture and rural development is a complex process that depends on numerous factors at different levels and across different aspects (Đokić, 2019). Agricultural sustainability requires a balance between economic, social, and environmental aspects, and a focus on integrating these components can contribute to the development of sustainable rural areas.

Sustainable management of rural resources

One of the most important strategic documents for the development of sustainable agriculture in rural areas is the Agriculture and Rural Development Strategy for the period 2014-2024. years. This strategy defines the following development goals: (Strategija poljoprivrede i ruralnog razvoja Republike Srbije za period 2014–2024. godine "Službeni glasnik RS", broj 85 od 12. avgusta 2014)

1. production growth and producer income stability;
2. growth of competitiveness with adaptation to the requirements of the domestic and foreign markets and technical-technological improvement of the agricultural sector;
3. sustainable resource management and environmental protection;
4. improving the quality of life in rural areas and reducing poverty;
5. efficient management of public policies and improvement of the institutional framework for the development of agriculture and rural areas.

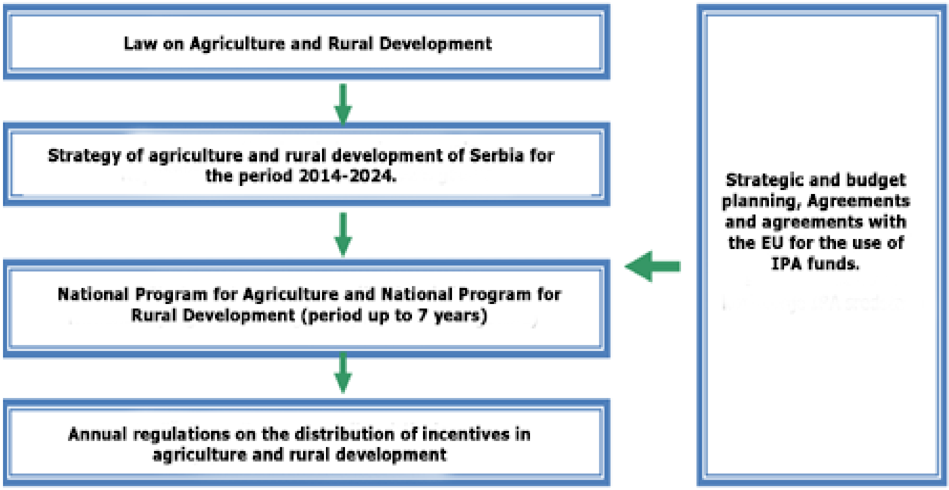

Figure 3. Policy planning system to support the development of agriculture and rural areas in the Republic of Serbia

Source: Systematization based on the Law on Incentives in Agriculture and Rural Development, the Law on the Budget of the Republic of Serbia and the Law on Government

The Republic of Serbia has approximately 5.06 million hectares of agricultural land, with 71% of this area, such as arable land, orchards and vineyards, being actively used. The remaining 29% consists of natural grasslands such as meadows and pastures. Most of the agricultural land, which is 65%, which is equivalent to 3.3 million hectares, is used as arable land. At the same time, there is an availability of 0.7 hectares of agricultural land per inhabitant, of which 0.46 hectares is specifically intended for the cultivation of arable land.

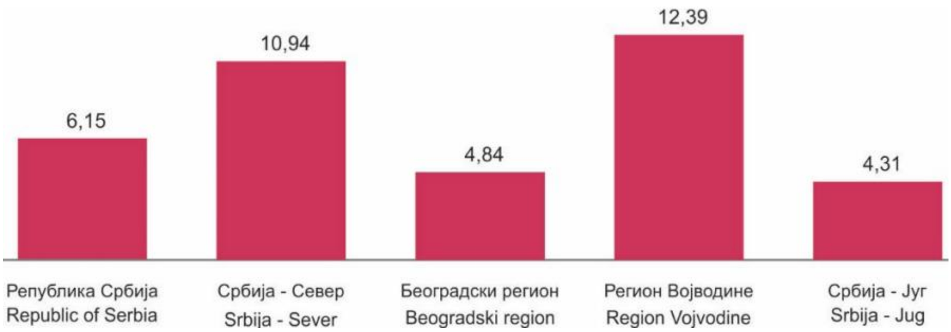

Figure 4. Arable land used - average per farm, ha

Source: Republički Zavod za statistiku Statistički godišnjak Republike Srbije, 2022.

According to estimates, every year there is a range of 200 to 350 thousand hectares of arable land and meadows that remain uncultivated, while the volume of unused agricultural land, including pastures, is significantly larger. Approximately 45% of agricultural land is considered suitable for cultivation, while the remaining part is land that is not suitable for agriculture or can only be cultivated with significant restrictions (Strategija poljoprivrede i ruralnog razvoja Republike Srbije za period 2014–2024. godine "Službeni glasnik RS", broj 85 od 12. avgusta 2014).

The problems faced by rural areas

Budgetary support for rural development in the Republic of Serbia remains insufficient, and the impact of sectoral policies on poverty reduction and the promotion of social inclusion is relatively limited (Kvrgić & Ristić, 2018). The process of aligning with EU regulations is an ongoing one, and institutional changes related to poverty reduction and social inclusion in rural areas are progressing slowly. Unfavorable demographic trends in rural regions compared to urban areas further complicate the situation.

Rural areas also face challenges stemming from regional and developmental disparities, a lack of local initiatives, reduced competitiveness, high employment in low-productivity agriculture, and limited access to education and digital literacy.

Public professional services and institutions for additional training are underdeveloped, and many local communities lack basic social services, leading to significant rural-urban and regional disparities in access.

Vulnerable subgroups within the rural population, including women, youth, the elderly, children, and people with disabilities, face social exclusion and an increased risk of poverty due to marginalization and limited financial resources. Local governments, which play a crucial role in supporting rural development, often have limited capacities, and the involvement of the rural population in local-level planning and decision-making processes is inadequate. Issues concerning these vulnerable social groups are typically addressed sporadically and narrowly rather than comprehensively (Kvrgić & Ristić, 2018).

Future directions of rural development through the influence of sustainable agriculture

A significant challenge facing policymakers in rural development and agriculture in the Republic of Serbia is how to promote creative activities in rural areas. This includes providing financial support to the creative sector, redefining the support system for small and medium-sized enterprises (SMEs) and rural entrepreneurship, promoting modern knowledge and information and communication technologies, increasing competitiveness, developing human resources, and implementing projects for the reconstruction and growth of rural areas (Kvrgić & Ristić, 2018). New rural development strategies tailored to the unique natural, cultural, historical, and traditional characteristics of each area should be designed to align with contemporary economic and societal needs.

The promotion of creative entrepreneurship aims to create better conditions for innovative economic endeavors that foster sustainable digitization of rural economies, produce attractive competitive products for the global market, and encourage innovation while respecting the principles of sustainable development and preserving the ecological integrity of rural areas (Kvrgić & Ristić, 2018).

Sustainable agriculture can be the primary source of income for those living in rural areas (Veličković & Jovanović, 2021). Rural areas in the Republic of Serbia face high rates of unemployment and poverty, limited investments, and inadequate institutional, organizational, and planning incentives.

Addressing these issues requires a systematic and planned approach (Đurić, 2018). Formulating a comprehensive development plan for rural areas is of utmost importance, encompassing the provision of necessary resources and the establishment of a conducive environment for its effective implementation (Veličković & Jovanović, 2021).

In this context, rural development will increasingly focus on diversifying agricultural activities. This means that with appropriate incentives, farmers should invest more in different sectors such as orchards, vegetable cultivation, livestock breeding, and alternative crops. Preserving natural resources such as water and soil will be a priority.

Therefore, sustainable agriculture is increasingly based on principles such as efficient irrigation, the use of organic fertilizers, and minimal soil erosion. Investing in the education of rural communities on sustainable agricultural practices and providing access to information through the internet and mobile technologies enable rural residents to better utilize resources and market opportunities.

Conclusion

Održiva poljoprivreda će imati veliki uticaj u budućem ruralnom razvoju širom sveta. Njen fokus na očuvanje prirodnih resursa, ekonomsku održivost i socijalnu jednakost doprinosi stvaranju otpornijih i prosperitetnijih ruralnih zajednica koje mogu zadovoljiti potrebe sadašnjih i budućih generacija. Ovakav oblik poljoprivrede važan je za izgradnju održivih sistema snabdevanja hranom koji će koristiti svima.

Ruralni razvoj značajan je za ekonomske i društvene aspekte razvoja u mnogim državama. Ruralna područja često su izložena siromaštvu i nedostatku resursa, ali održiva poljoprivreda može imati veliku ulogu u transformaciji tih područja. Strategije i politike usmerene ka održivom razvoju ruralnih područja trebaju da se fokusiraju na efikasno upravljanje prirodnim resursima kao osnovnom resursu za poljoprivredu. Podizanje svesti i promovisanje održive poljoprivrede i ruralnog razvoja značajno je za rešavanje izazova u vezi sa proizvodnjom hrane, degradacijom životne sredine i smanjenjem siromaštva. Vlade, nevladine organizacije, poljoprivredna gazdinstava i zajednice treba rade zajedno na postizanju ovih ciljeva i oblikovanju održive budućnosti ruralnih područja.

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