
THE ROLE OF MODERN INNOVATIONS IN THE TRANSFORMATION OF SERBIAN AGRICULTURE TOWARDS SUSTAINABILITY

Anita Klikovac¹, Marijana Milunović², Ana Anufrijević³, Jovan Rudež⁴

*Corresponding author E-mail: anitaklikovac@yahoo.com

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ABSTRACT

The agricultural sector and food production are increasingly striving to find answers to complex challenges, among which climate change stands out in particular. The paper states the role of innovation in the agricultural sector, as well as the analysis of challenges in the sustainable development of the agricultural sector. From conventional to digital agriculture, the paper analyzes all aspects in order to find the best solutions towards creating a sustainable transformation of Serbian agriculture. Strategic investment in innovation is a link between traditional production and modern, ecologically responsible agriculture that will meet the needs of current and future generations.

Introduction

The concept of sustainable agriculture implies the development of this sector based on balancing the economic, social and ecological aspects of sustainability. At the end of the 1980s, the Food and Agriculture Organization (FAO) defined this approach as a development model that allows for the preservation of natural resources such as soil,

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- 1 Anita Klikovac, PhD student at the Faculty of Security, Ministry of Internal Affairs, Department for Emergency Situations, Belgrade, Serbia, Phone:+381666602467, E-mail: anitaklikovac@yahoo.com, ORCID ID (<https://orcid.org/0009-0003-8616-7564>)
 - 2 Marijana Milunović, Full professor, Union – Nikola Tesla University, Faculty of Economics and Finance, Cara Dušana 62–64 Belgrade, Serbia, Phone:+381629646280, E-mail: mmilunovic@unionnikolatesla.edu.rs, ORCID ID (<https://orcid.org/0000-0003-3791-5098>)
 - 3 Ana Anufrijević, Full professor, Union – Nikola Tesla University, Faculty of Economics and Finance, Cara Dušana 62–64 Belgrade, Serbia, Phone:+38162262072, E-mail: aanufrijevic@unionnikolatesla.edu.rs, ORCID ID (<https://orcid.org/0000-0001-5476-440X>)
 - 4 Jovan Rudež, Assistant professor, University Business Academy in Novi Sad, Faculty of Economics and Engineering Management, Cvečarska 2 Novi Sad, Srbija, Phone:+381600503133, E-mail: jovan.rudez@gmail.com, ORCID ID (<https://orcid.org/0000-0003-4910-4946>)

water, and the genetic potential of plants and animals, while being environmentally acceptable, economically profitable, technically feasible, and socially sustainable (FAO, 1989, p. 5).

In the modern context, the agricultural sector and food production are increasingly striving to find answers to complex challenges, among which climate change stands out. The modern approach implies respect for the principles of sustainability and a focus on achieving the goals defined by the 2030 Agenda for Sustainable Development adopted by the United Nations (UN, 2015). This agenda includes 17 main goals and 169 sub-goals, which together cover the three basic dimensions of sustainable development: economic progress, social justice and environmental protection. The signatories of the Agenda have undertaken to direct their resources in a responsible manner in order to achieve the set goals by 2030.

In addition, in the light of increasingly intense global changes and increasingly complex challenges, innovation, investment in science, research and development, as well as investment in education, are becoming key factors for building sustainable and competitive agriculture — both at the level of individual enterprises and within national economies around the world.

The development of agriculture and rural areas in Serbia is directed towards sustainable solutions and greater use of innovations, which is one of the strategic priorities of the Government of the Republic of Serbia. Within the “Strategy of agriculture and rural development for the period 2014-2024”, one of the key segments (Area 7) refers to technological progress and modernization of agricultural production and processing (Official Gazette of RS, no. 85/14).

In addition, in 2021, the “Strategy of scientific and technological development of the Republic of Serbia for the period 2021-2025 - The power of knowledge” was adopted (Official Gazette of the RS, No. 10/21), with the intention of accelerating the economic progress of the country and improving the quality of life of citizens through the development of knowledge, science, technology and innovation, as well as to improve Serbia’s integration into the European research area.

This chapter aims to analyze the innovative capacities of Serbian agriculture, with a focus on the extent to which investments in research, development and application of innovations in this sector contribute to the achievement of the sustainable development goals of the United Nations until 2030 (UN Serbia, 2018).

The role of innovation in the agricultural sector

In modern conditions, no sector of the economy can expect success if it does not implement continuous innovation and improve its operations. For this reason, companies strive to optimize costs and increase profitability. Nevertheless, the achievement of economic profit should not be carried out at the expense of environmental degradation and endangering human health, which is in line with current regulations and numerous

scientific analyses.

The innovations that are introduced must be in accordance with the principles of sustainable development, which means that they should include economic, environmental and social aspects. Innovation activity means activities aimed at the development of new products, technologies, processes and services or significant changes to existing ones, all with the aim of meeting the needs of the market.

Innovation is defined as the successful commercial application of new or significantly improved products, services or processes - which may include improvements in technical features, components, materials, software, user experience and other functional elements. In addition, innovations can also include new marketing or organizational approaches in the way of doing business and managing relations with the environment (Official Gazette of RS, No. 55/2013).

An innovation is defined as a new idea, procedure or object that an individual or group perceives as something they have not used or known before. The process of spreading innovations, i.e. diffusion, is a form of social change and involves communication between people with the aim of transmitting new solutions. During this process, participants actively exchange information for better mutual understanding. The peculiarity of diffusion is reflected in the fact that it is aimed precisely at new ideas (Rogers, 2003). Diffusion theory, developed by rural sociologists, plays a significant role in explaining how changes occur in society, especially with regard to the adoption of innovations in rural and agrarian communities. It tries to predict the reactions of individuals and social groups to innovations, taking into account their personal characteristics, social connections, time and the very nature of the innovation. This theory is particularly relevant in the case of switching to organic farming. Although it was created during the period of intensive agricultural development during the so-called "green revolution", diffusion theory is also applied in new contexts such as organic agriculture, which focuses on ecological sustainability and environmental protection (Padel, 2001).

It is important to make a clear distinction between inventiveness and innovation. Invention refers to scientific or technical discoveries and is always related to the creative process, while innovation refers to the application of new or existing ideas in a new way (Grujić et al., 2015, p. 210). A significant part of modern technologies belongs to sustainable technologies, because they contribute to the improvement of various product properties (Grujić et al., 2015, p. 211). Although the agricultural sector has a certain potential for improvements through innovation, this area still does not receive enough attention. This is especially pronounced in regions with an older agricultural population, which is often skeptical of changes and slower to accept new solutions.

In today's time of continuous global changes, it is necessary to constantly adapt and follow modern trends, along with the continuous introduction of innovations. In the agricultural sector, where resources are often limited, it is crucial to make optimal use of available ingredients and apply innovation in order to achieve the best possible business

results. The agricultural and food sector has undergone numerous transformations over the course of two centuries. In response to environmental challenges and pollution problems caused by conventional agriculture, organic and other sustainable agricultural production has developed. Agriculture is specific due to its dependence on various external factors, resources, knowledge and innovations, as well as the way of transferring new technologies. The application of innovations in this sector is not a simple process and it is not enough to provide financial resources and experts, because experiences from many countries, both developed and developing, have shown that this in itself is not a guarantee of successful modernization of agriculture and rural development (Tomaš Simin & Janković, 2014).

Innovations in agriculture are not limited to agricultural holdings, but should encompass the entire value chain, including government policies aimed at agribusiness development (Vanclay et al., 2013). The connection between research, innovation and increasing productivity is gaining more and more importance, so in this context the role of the state is extremely important.

Recent research shows that nanotechnology has significant potential for a positive impact on the agri-food sector. It can reduce the negative effects of agricultural practices on the environment and human health, while increasing food security and productivity, while promoting social and economic balance.

The concept of sustainability in this context implies production systems that aim to increase yields without harming the environment and with appropriate cultivation of agricultural land. Considering challenges such as global population growth and climate change, the application of nanotechnologies and nanomaterials in agriculture can significantly contribute to sustainability.

The efficiency of the use of fertilizers and pesticides can be improved through the use of nanocarriers and compounds, which allows for a reduction in quantity without loss of productivity. Nanotechnologies also contribute to reducing waste, improving production and reusing waste through recycling. Nanosensor technology is driving the development of precision agriculture, enabling more efficient management of resources such as water and energy (Fraceto, 2016).

Contemporary challenges and sustainable development of the agricultural sector

In modern society, no economic sector can successfully advance without the constant introduction of innovations, application of new approaches and improvement of business activities. At the same time, economic benefits must not be achieved at the expense of the environment and human health. The innovations that are implemented must be harmonized with the modern requirements of sustainable development, that is, they must satisfy economic, ecological and social criteria. In this process, legal regulations and accompanying institutional mechanisms play a key supporting role.

In the agricultural sector, it is crucial to efficiently use available resources, especially

natural ones, as well as properly apply innovations. In order to protect the environment, but also to increase yields and productivity, different agricultural systems have been developed over time. Nevertheless, even at the beginning of the 21st century, there is still a dilemma as to which type of agriculture should be focused on.

Low productivity in the agriculture of less developed countries represents a significant challenge, mainly due to the insufficient application of modern resources and the presence of other negative factors. Therefore, these countries need technological innovations that will be adapted to the specifics of each region, and that will encourage the modernization of agriculture, while preserving traditional values. It is important to emphasize that today's agricultural system can be considered sustainable and successful in the long term only if it simultaneously improves human health, protects the environment, ensures sufficient food production and ensures an acceptable income for farmers.

Sustainable agricultural development in modern conditions

Sustainable development is defined as development that meets the needs of the present generation without jeopardizing the ability of future generations to meet their needs (World Commission on Environment and Development, 1988). The concepts of sustainable development and rurality, as well as their combination — sustainable rural development and sustainable agriculture, are often discussed in the literature. Although they appear similar, each of these concepts includes different ideas related to agriculture, rural development, nature and landscape conservation, as well as the role of key actors such as farmers, rural populations and the state (Tovey, 2008).

Sustainable agriculture mainly focuses on farmers and ecological conditions at the farm level, while sustainable rural development covers a wider regional framework and includes a wider range of actors because, in addition to agriculture, it also includes other aspects of rural development (Murdoch et al., 2003). In doing so, priority is given to long-term sustainability instead of short-term profit, and sustainability is also viewed in the context of the social acceptability of the agricultural sector.

In essence, sustainability is a means to improve the social, economic and environmental acceptability of the sector. Sustainable agriculture is tasked with solving numerous technical challenges, while simultaneously providing socio-economic and environmental aspects (Hermans et al., 2010).

Sustainable agriculture represents one of the key segments within sustainable development and is considered a modern approach to the development of this sector. Given the close connection between agriculture and the environment, sustainable development in agriculture must be a continuous process in order to preserve natural resources for future generations.

Emphasizing the importance of agricultural activity and the importance of sustainable rural development, especially in countries with a less developed economy where

many rural residents depend on agriculture as a source of income and employment, it becomes clear that this topic has a high priority in planning future development. Sustainable development requires the proper management and protection of natural resources, as well as appropriate management of technological innovation and adequate administrative structures, in order to enable the continuous satisfaction of people's needs now and in the future.

This approach implies the preservation of key elements such as soil, water and biodiversity, with the application of technologies that do not threaten the environment, and at the same time are economically and socially acceptable (Bastan et al., 2018).

It is necessary to adopt the concept of sustainable agriculture, which is adapted to the specific conditions of each country, as a fundamental resource for future development. This approach enables efficient and rational use of natural and other resources in accordance with the environment, while ensuring food safety for both current and future generations. However, the application of the concept of sustainable development represents a complex task in modern conditions, because it includes a series of measures that should maintain economic and social stability, based on environmental protection, which can contribute to a significant improvement in the quality of life of the population (Simiton, 2015). The sustainability of agricultural systems has become a central topic in debates about human survival. In an age of climate change, market globalization and rapid technological progress, an accurate assessment of the sustainability of food production systems becomes crucial.

One of the important questions is the extent to which intensive agricultural systems affect the environment and how ecologically sustainable they are (Tait & Morris, 2000). Managing the relationship between plants and the environment, especially in the context of global climate change, represents one of the most important challenges of modern sustainable development in agriculture.

Sustainable agriculture has a special importance in modern society because it provides solutions for needs that conventional agriculture has not been able to fully satisfy. It is a comprehensive concept that includes advances in agricultural production management and the improvement of agricultural technologies. Its importance is growing, especially considering that the intensive development of conventional agriculture after the Second World War was not able to respond to all the challenges of the modern era.

Today, an ideal agricultural system is considered to be sustainable only if it simultaneously improves human health, benefits both producers and consumers, protects the environment, and provides sufficient food for the growing world population (Singh et al., 2011). Agricultural practice today offers new development models, which is confirmed by the rapid growth of the agricultural bio-economy with an increasing emphasis on ecological values.

In many countries, an intense wave of innovation in the agri-food sector is visible, which results in the expansion of the offer of products and services, the development

of new perennial crops, the production of biomass, healthy food and ecological non-food products from agricultural raw materials. These innovations contribute to the development of the so-called "new agriculture" which is oriented towards sustainability and responsibility in social, economic and environmental terms (Jordan et al., 2008).

Modern agriculture rapidly increases productivity, but at the same time leads to excessive consumption of resources and energy, as well as to the degradation of the agricultural environment. Inadequate management of agricultural development damages the environment and significantly threatens the sustainability of agricultural development. In this context, the circular economy has emerged as an effective model based on the principles of sustainable development, which enables the coordinated development of the economy and the environment through efficient waste management. This model, known as the recycling economy, is based on the concept of ecological agriculture without pollution and represents a path towards progressive and sustainable development (Jun & Xiang, 2011).

Conventional agriculture

Conventional agriculture is still the most widespread model of agricultural production in the world, primarily because of its high economic profitability, especially when it comes to large-scale production. This system allows the use of chemical agents, but within the legally regulated norms. In professional literature, conventional agriculture is often characterized as a model that requires large capital investments, a high degree of mechanization and profitability, with a wide application of mineral fertilizers, pesticides and herbicides, and intensive ways of growing plants and animals (Comer et al., 1999).

However, certain practices characteristic of this type of production - such as the use of agrochemicals - have negative consequences for human health and the environment. The use of pesticides has led to various environmental and health problems, which has encouraged the development of alternative models of agriculture that limit the use of chemicals without causing a significant drop in yields. Although the yield in organic farming is usually lower compared to conventional production, it depends on the type of crops, regional conditions and technologies used. Despite this, conventional production systems generally yield higher profits.

From the point of view of environmental protection, the advantages of organic production - such as reduced use of chemicals, preservation of soil and water fertility, as well as improvement of biodiversity - are significantly more pronounced than in conventional systems. However, due to better economic profitability, conventional agriculture is still dominant. Despite its ecological disadvantages, it is possible to improve its sustainability and reduce the negative impact on the environment through the gradual inclusion of certain organic practices within conventional production (Pimentel et al., 2005).

According to research by Te Pas and Risa (2014), in developed countries, organic

agriculture generally brings lower yields and lower profitability compared to conventional agriculture. In middle-developed countries, organic production has a slightly better position, while in the least developed countries this type of production is often more profitable - thanks to lower labor costs and the availability of cheaper manure.

In theory and practice, it is often emphasized that organic agriculture is more environmentally friendly, while conventional is more economically profitable. However, one should not strive for exclusivity. It is necessary to strive for a balance between economic and ecological interests, while respecting the social context. This implies the application of innovative approaches within conventional production, with controlled and limited use of chemical and synthetic agents in crop and livestock production.

Modern agriculture as a driver of sustainable development and green transformation

Sustainable development implies a balanced approach that includes economic, ecological and social aspects of development, whereby institutional support is of key importance for the successful implementation of this concept. The idea of sustainable development and ecologically oriented economy appeared in the second half of the 20th century, and the end of that century and the beginning of the 21st were marked by the intensification of global initiatives, forums and research aimed at this issue.

The concept of green economy is closely related to sustainable development. Its advocates believe that the modern economic system, although it has contributed to the improvement of living standards, has numerous shortcomings, among which stand out environmental problems such as climate change, loss of biodiversity, overexploitation of natural resources, as well as pronounced social inequalities, poverty, shortages of food, water and energy.

The green economy is proposed as an alternative to the existing model, with the aim of enabling a long-term increase in social well-being, without jeopardizing the natural environment and resources needed by future generations. Special importance to this concept was given at the United Nations Conference on Sustainable Development, held in 2012 in Rio de Janeiro (Rio + 20), where key documents such as the Rio Declaration and Agenda 21 were adopted, which further confirmed the green economy as an important path to a sustainable future.

Sustainable agriculture can be viewed from several angles, depending on the professional field. From an agronomist's point of view, it implies the long-term preservation of food production. Environmentalists see it as a method that makes it possible to meet food needs without harming natural resources. The economic aspect of sustainable agriculture is reflected in the rational and long-term efficient use of resources. For sociologists and anthropologists, this form of agriculture has a wider meaning - it preserves cultural heritage and respects the social dimensions of the development of rural areas (Vujičić & Ristić, 2006).

The progress of sustainable agriculture and the countryside can be ensured through the interconnection and cooperation of the primary (agriculture), secondary (manufacturing) and tertiary sectors (services), in various forms. In that process, in addition to the key role of the state, local initiatives that contribute to the development and strengthening of rural communities are extremely important (Vujičić et al., 2012).

Integration of the bioeconomy into the circular development of the agricultural sector

The bioeconomy is based on the use of renewable biological resources in order to produce food, biological products that are not intended for food, as well as green energy. Its application includes various sectors such as agriculture, forestry, fishing, food industry, pulp and paper industry, parts of the chemical industry, biotechnology and energy (Ronzon et al., 2017). According to OECD (2006), the bioeconomy implies the use of biological products and processes with the aim of achieving benefits both for individuals and for society as a whole.

When we talk about the development of the bioeconomy, it is important to point out that the key sources of biomass for energy production are precisely agriculture, forestry and certain types of biological waste. The most important forms of biofuels include liquid fuels such as biodiesel and bio-oil, but also solid biofuels such as pellets and torrefied biomass. Biomass originating from agriculture includes the production of liquid fuels, bio-oil from wood pulp and pellets. At the global level, the available biomass base for energy production from biological sources represents a significant alternative to fossil fuels, which contributes to the sustainable development of the agricultural sector (Mathews, 2009).

In addition to the green economy, one of the key concepts closely related to the bioeconomy is the concept of circular economy. This model implies the introduction of business practices aimed at increasing efficiency in the use of resources, with a special emphasis on proper waste management. According to some authors, circular economy is considered a narrower term in relation to green economy and bioeconomy (Birner, 2018). Nevertheless, all three concepts represent compatible directions of development that are in accordance with the principles of sustainable agriculture and the entire economic system.

In the modern context, the circular economy is attracting more and more attention at the global level as a potential solution for overcoming the existing model of production and consumption, which is based on constant economic growth and intensive use of natural resources. The basic idea of the circular approach is to establish closed production cycles that enable reuse of raw materials and energy savings, unlike the traditional linear model, where raw materials become waste after one use (Ghisellini et al., 2016; Urbinati et al., 2017). This approach seeks to establish a balance between economic development, environmental protection and social responsibility.

Digitization of agriculture: Precision agriculture in the function of increasing efficiency

Today, modern information and communication technologies (ICT) play a key role in the economy and society, including in agriculture (Ristić, Vujičić & Dimitrijević, 2020). Innovation in this sector is no longer limited to new plant varieties and animal breeds, but also includes technologies such as satellite imagery, sensors and drones.

Agriculture has always benefited from technical and technological progress. The industrial revolution brought mechanization, the use of artificial fertilizers and chemicals, while the modern age introduced genetic engineering and automation. Today, the digital era provides great opportunities for integrating ICT solutions into the model of precision agriculture. The success of precision agriculture is measured not only by economic but also by ecological and social benefits. It is particularly important for increasing the profitability of farmers and saving financial and other resources (Zhang et al., 2002). Also, precision agriculture contributes to the development of smart villages.

Although precision agriculture represents an innovative approach, it is still significantly less represented in practice compared to conventional agriculture. Its purpose is, among other things, to increase the efficiency of resource use. This approach involves the use of various technologies, such as sensors, information systems, advanced machines and management software, with the aim of optimizing production (Gebbers & Adamchuk, 2010). It is believed that the application of precision agriculture in the world will increase significantly, but this requires a modern information infrastructure, including broadband Internet and other supporting technologies.

Precision agriculture involves intensive data collection directly in the field, often in parallel with the operation of machines. Analysis of this data is key to understanding yield variability. Wireless sensor networks are a new technology that enables the collection and processing of data from sensors distributed in the field in real time (Camilli et al., 2007). By using these networks, precision agriculture can increase efficiency, productivity and profitability while reducing negative environmental impacts.

For the application of numerous technologies in agriculture, the goal is to make products safer and to reduce negative impacts on the environment, which is in line with the principles of sustainable development. Precision agriculture is emerging as a key part of a broader strategy to achieve this goal. This approach uses remote sensing technologies and is an effective tool for achieving sustainability. Precision agriculture brings numerous benefits, including increased profitability, productivity, quality of crops and final products, improvement of farm living conditions, food security, environmental protection, development of rural economy and better management of resources through more rational use of inputs (Liaghat & Balasundram, 2010). However, the development of precision agriculture is slowed down by various challenges, such as the high cost of equipment, the complexity of working with modern devices that require specialized training, problems in servicing and maintaining equipment, as well as strict requirements in terms of standards for sensor networks.

Conclusion

Modern innovations are the key driving force behind the transformation of Serbian agriculture towards a sustainable and competitive production system. Faced with challenges such as climate change, land degradation, workforce reduction and the need to conserve natural resources, Serbian agriculture increasingly has to rely on technological advances in order to preserve productivity and at the same time reduce negative impacts on the environment.

The application of precision agriculture, information technologies, smart sensors, automated irrigation systems and satellite crop monitoring enables more efficient management of resources such as water, fertilizers and energy. This not only improves the quality and quantity of production, but also contributes to the preservation of biodiversity and the reduction of harmful gas emissions. Innovations in the field of biotechnology and genetic improvement of plants also contribute to resistance to diseases, drought and other stress factors, which is especially important in the conditions of increasingly pronounced climate changes.

In addition to environmental benefits, modern innovations also have social and economic significance - they enable the creation of new jobs, the development of rural areas, greater food security and a better position of agricultural producers on the domestic and foreign markets. However, in order to fully realize these benefits, it is necessary to provide institutional support through education, subsidies, research and development, as well as encouraging cooperation between scientific institutions, state authorities and the private sector.

In conclusion, a sustainable transformation of Serbian agriculture cannot be imagined without strategic investment in innovation. They represent a bridge between traditional production and modern, ecologically responsible agriculture that will meet the needs of current and future generations.

Conflict of interests

The authors declare no conflict of interest.

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