

# SIGNIFICANCE OF INNOVATIONS AND APPLICATION OF INFORMATION - COMMUNICATION TECHNOLOGIES IN AGRICULTURE AND RURAL DEVELOPMENT OF SERBIA<sup>1</sup>

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## Abstract

*Innovations and the application of information and communication technologies have a driving role in the efficient development of smart agriculture. The application of new information and communication technologies and the digitization of the agricultural sector represent a great potential for improving rural development through increasing profitability, productivity, sustainability and competitiveness. Modern communication approaches and technologies, from artificial intelligence and robotics to the Internet of Things (IoT), enable significant support and assistance to agricultural holdings and businesses. The results of the research in the paper indicate the possibilities of encouraging rural development based on the use of information and communication technologies through reducing the digital divide, solving existing challenges in terms of creating reliable access to modern communication technologies, strengthening resources for the application of technologies, encouraging awareness, developing skills and training human resources in rural areas.*

**Key words:** *innovation, rural development, smart agriculture, information and communication technologies, IoT-Internet of Things.*

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- 1 Paper is a part of research funded by the MSTR I RS, defined by the contract no. 451-03-47/2023-01/200009 from 3<sup>rd</sup> February 2023.
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## Introduction

The level of technological progress, access to information and improvement of acquired knowledge are of great importance for the sustainable development of rural communities. According to the basic nature of agriculture, timely access to quality information in today's conditions of business and life of the rural population can play a crucial role from the point of view of the success of the implemented production and social activities (Subić, Kljajić, Jelocnik, 2017).

The meaning of innovation as a term has changed over time depending on changes in the environment and technological progress. The most commonly accepted definition indicates innovation as a multiphase process in which the organization transforms its ideas into new, improved products, services or processes in order to advance, compete and successfully differentiate itself in its market (Baregheh, Rowley, Sambrook, 2009). The term innovation in agriculture is associated with the application of information and communication technologies in the digitalization of agricultural production management and precision agriculture (Hunt, Daughry, 2018). Other authors give the following definition: "innovation is the application of a new or significantly improved product (goods or services) or process, a new marketing method in business, work organization, or relations between a business entity and its environment (Manual, 2005). In the agricultural sector, innovations include new knowledge and technologies related to primary production, processing and commercialization (Asenso-Okyere, von Braun, 2009). Innovations in agriculture are new outputs and methods used to increase production, yield or quality (Akkoyunlu, 2013). The direct effects of innovation refer to the achievement of higher profitability, while the indirect effects refer to higher productivity and employment growth (Berdegue, Escobar, 2002).

Digital agriculture, smart or "e" agriculture uses a wide range of devices, tools and applications. They range from basic technological solutions to various modern "digital" forms that have integrated systems, various digital platforms, software applications (for example drone control), satellite navigation, drones, robotics, sensors for data collection and software for their processing and analysis (OECD, 2018). It is indisputable that technological development in agricultural production constantly brings hundreds of new solutions, which are primarily oriented towards stabilization and growth of productivity, while globally a relatively small number of producers decide to implement techno-

logical innovations. Therefore, the transformation of traditional agriculture is not only a problem of investing in technological progress, but a problem of choosing an adequate object of investment, which is primarily a task of the available knowledge of the producer (Njegovan, Jelocnik, 2013).

### **Methodology**

During the research, the deductive method, the method of induction, analysis and synthesis was used in order to monitor and analyze the selected data and the comparative method. The research is based on relevant data in the observed period of the past ten years. The structure of the work and ongoing research are aligned with the use of relevant data from the Statistical Office of the Republic of Serbia, as well as with the use of current scientific and professional domestic and foreign literature. Research in the work based on the review of scientific and professional literature, as well as the analysis of the collected data, indicate the trends and possibilities of applying information and communication technology in order to improve agriculture and rural development. This indicates the need for further research in this area in order to develop rural areas.

### **Results and Discussion**

World experience has shown that countries that continuously invest in research and education are economically more successful, that is, more resistant to negative effects resulting from crisis situations (Zubović et al., 2013). In recent decades, a high correlation has been determined between investments in research and development and the degree of sustainability of development of all sectors of the economy. The development of science, education and technology is widely accepted and society must support research and innovative activity that will generate future growth and development (Subić, Kljajić, Jelocnik, 2017).

The field of innovations in Serbian agriculture is largely influenced by the comprehensive financial support of the state. Insufficient and low orientation of the state in financial support towards agriculture indicates that this sector receives a smaller part of state spending in relation to its contribution to the economic value (Paraušić, Roljević Nikolić, 2021).

In table no. 1 presents comparative views of investment in research and development as a percentage of gross domestic product in Serbia and the European Union in the period 2010-2019.

**Table 1.** Investments in research and development as a % of GDP in Serbia and the EU, 2010-2019.

Year	EU	Serbia
2010	1,92	0,70
2011	1,96	0,68
2012	2,00	0,85
2013	2,02	0,68
2014	2,03	0,72
2015	2,04	0,81
2016	2,04	0,84
2017	2,08	0,87
2018	2,11	0,92
2019	2,14	0,89

Source: Eurostat, 2020.

Investments in research and development as a percentage of gross domestic product in Serbia in the observed ten-year period (table no. 1) show that it is uniform and ranges from 0.68 (2011, 2013) to the highest parameter of 0,92 in 2018. Despite the slight increase, the data indicate that investments are still far below the European Union average. Investments in research and development from state budgets in the European Union amounted to about 100.7 billion euros in 2020, i.e. approximately 0.8% of the gross national product (EUROSTAT, 2021). In the report of the European Commission on the evaluation of innovations, it is stated that Serbia achieved a significant growth of about 30% in the field of innovations (European Innovation Scorecard, 2021). This indicates an increase in investment in the areas of human capital, digitalization and the innovative economy. However, data indicate that in 2018, Serbia was at the level of 58% of the European Union average, and that this percentage increased to 66.2% in the next three years, which indicates that it is still below the European Union average (EUROSTAT, 2021 ). Statistical data also indicate an unfavorable situation in Serbia in the area of investment in research and development in agriculture, as well as when it comes to the index of state expenditures directed at agriculture. The index of state expenditures directed at agriculture represents the ratio of the share of agricultural expenditures in state expenditures and the share in the country's gross domestic product.

**Table 2.** Index of state expenditures focused on agriculture

Year	Index
2015	0,25
2016	0,24
2017	0,32
2018	0,33
2019	0,33

Source: SORS, 2020.

In the observed five-year period (2015 - 2019), the data from Table 2 indicate a low index of state expenditures aimed at agriculture, whose value is below 1 and ranges from 0.24 to 0.33 (SORS, 2020). This indicates a low level of innovative capacity of the agricultural sector, which leads to stagnation and distance of Serbia from the realization of a number of set sustainable development goals (SORS, 2020).

In order to encourage rural development and social inclusion of the population from rural areas in the application of modern information and communication technologies, it is important to take into account several parameters, among which: data on the use of Internet communication, computer literacy and the educational structure of the rural population. Table no. 3 summarizes the percentage of computer and internet connection ownership and the ratio of that percentage between rural and urban areas.

**Table 3.** Percentage of the population who own a computer, mobile phone and internet connection

Type of settlement	Computer	Mobil phone	Internet connection	Broadband internet
Urban	81,6	96,3	87,1	87,0
Rural	61,8	90,3	70,4	70,1

Source: SORS, 2020.

Based on the data of SORS from 2020, we can conclude that there is a pronounced digital gap between urban and rural areas in Serbia. This is indicated by the fact that slightly more than half of the households in Serbia own a computer. Two-thirds of households have an Internet connection (SORS, 2020). The main limiting factors should be found in: too high equipment costs

(20.4%), high access costs (10.9%), lack of skills (9.4%), unavailability of internet in certain areas (7.6%) ( Jelić, Kolarević, 2021).

**Table 4.** Population with computer literacy and type of settlement (%)

Type of settlement	Computer literate person	Person with partial computer skills	Computer illiterate person
Urban	44,09	15,11	40,80
Rural	19,84	14,29	65,87
<b>Gender structure</b>			
Male	20,93	15,58	63,49
Female	18,74	13,02	68,24

Source: SORS, 2020.

Data from table no. 4 summarizes the state of computer literacy and indicate the existence of a large gap in computer literacy, whereby 65.87%, which represents almost two thirds of the rural population, are computer illiterate. Only 14.29% of the rural population has some kind of skills. There is a similar representation if the gender structure is observed, according to which women have a lower percentage of computer literacy (SORS, 2020).

In addition to improving and improving Internet access and reducing costs, the most important prerequisite for the introduction of innovations and the use of new communication technologies is education. Based on the data from table no. 5 we can conclude that the educational characteristics of human resources in rural areas are noticeably less favorable than the urban population. According to the data from table no. 5 in rural areas, there is a dominant representation of human resources with a high school diploma (42.4%).

**Table 5.** Demographic indicators and educational structure in rural areas

Element	Serbia	Rural areas
% without formal education	13,7	23,4
% with elementary education	20,8	27,7
% with middle school	48,9	42,4
% higher education	16,2	6,1
% unknown	0,4	0,4

Source: SORS, 2018.

A particularly unfavorable trend is in the structure of human resources in rural areas with the percentage of basic and no formal education amounting to 51.1%. The educational structure of the workforce due to the low represen-

tation of highly educated personnel (6.1%) in rural areas is a limiting factor for the implementation of innovative and information and communication technologies. Formal education, especially of farm managers, is low and at an unsatisfactory level. More than half of managers (54%) perform their duties on the basis of experience gained from practice, a somewhat significant percentage graduated from high school (30%), while only 5% graduated from college or university. These data indicate not only the difficult access to innovations, but also the difficult adoption of innovative forms of business. In order to stop such trends, the need to include the rural population in innovative formal and informal educational programs has been expressed (Nedeljković, Zečević. Zečević Stanojević, 2023).

One of the limiting factors is the insufficiently efficient transfer of knowledge and innovations in the agricultural sector and rural areas, as a result of numerous limitations in the functioning of the agricultural advisory service (Djurić, 2020). Also, the high costs of introducing innovations and insufficient motivation of farmers to invest in the application of innovations, because the results are not quickly visible, are one of the limiting factors (Stanojević, 2019). The motivation of the rural population in the application of innovations is largely influenced by the unfavorable management structure in agricultural holdings. The management structure is dominated by older people. This is indicated by the fact that over 40% of managers are in the structure of 65 years old, who are poorly motivated to introduce innovations and are oriented towards traditional forms of business. The data also indicate a low percentage of human resources in rural areas who are represented in the management structure in the age category up to 45 years, whose representation is only 11.8%. Particularly worrying is the fact that the share in the category of younger managers and administrators, who are responsible for the introduction of innovative and modern communication changes in business, is in constant decline (SORS, 2020). Access to information, and through it to compressed knowledge and innovative messages, members of the rural community most often achieve through the available IT infrastructure (including local printed and electronic media) or through the organization of trainings, courses, demonstration workshops and similar activities. It is important to point out the necessity for the mentioned activities to be organized by representatives of the local community, a network of public and private institutions in the function of the development of knowledge transfer and the introduction of innovations in rural areas (departmental ministries, advisory and professional services, schools and faculties, regional development agencies, chambers of commerce

, associations of farmers and agricultural cooperatives and others) (Subić, Kljajić, Jelocnik, 2017).

Innovations contribute to the development of rural areas and the agricultural sector in various ways, primarily in the areas of: establishing a precise analysis of the situation, improving the system of data collection, analysis and processing, increasing yields, improving quality, processing, preservation and storage, increasing productivity, reducing costs, economic and profitability of production. That is why it is necessary to create more favorable conditions for financing innovations and the research and development potential of the agricultural sector of Serbia through improving international cooperation, investing in rural infrastructure, investing in education and raising awareness about the necessity of introducing innovative information and communication technologies, research and advisory services, development of information technology in order to improve business and production capacities.

### **Application of innovations and information and communication technologies in agriculture**

One of the fields that can contribute to better and more efficient agricultural production is information technology. Innovative information and communication technologies such as Cloud computing, big data, artificial intelligence and deep learning have a wide and effective application in smart farming and agriculture. IoT technology - Internet of Things, smart devices, are transforming the agricultural sector, providing farmers with access to real-time data on environmental conditions. Smart electronic devices independently perform some functionality, where they are usually sensors that measure some quantity that is needed for further analysis on the basis of which decisions will be made and actions aimed at improving yields. With the use of actuators, some of these decisions can be implemented. By combining real-time IoT data with accurate geospatial data, farmers can implement precision agriculture, resulting in higher yields, reduced waste and more sustainable practices. These devices have a diverse field of application, and they can also be very diverse. They are used to measure soil parameters, such as, for example, humidity and temperature of the soil, humidity and temperature of the air, strength of UV radiation and others, in order to use adequate agrotechnical measures, irrigation or use of certain preparations (Quy, et al., 2022). They can be combined with video surveillance or aerial crop condition recording using drones in different spectrums. In the case of smart livestock, IoT devices can be placed

on each head with various sensors, in order to monitor heart rate and temperature, RFID for access control or access to GPS devices for tracking movement (Shailendra Mishra et al., 2023). It is important to point out the existence of different communication possibilities between devices. These devices can be permanently networked for real-time data monitoring and provide the ability to store and collect data at multiple locations. The main advantage of using these technologies is reflected in the ability to collect a large amount of data that can be used to monitor the desired resource. Based on their analysis, further courses of action can be determined. Some of these measures can be implemented automatically, as in the example of irrigation. Data from the sensors is the basis for creating a map of soil moisture, on the basis of which irrigation systems can be activated only where necessary and to the desired extent. Of great importance is the need to include external data in the decision-making system (for example, making a decision about the need for irrigation based on the meteorological forecast). In order to efficiently use data, quality processing is required. That is why it is important to highlight the possibility of applying artificial intelligence and machine learning in this field (Ribeiro et al., 2022) and the application of Cloud computing. This involves collecting data over local networks that are sent to the Cloud for analysis. In the case of application in agriculture, certain difficulties appear here. The reason lies in the fact that agricultural farms are located in remote areas, without modern infrastructure. Therefore, collecting data and sending it for processing is a big challenge when it comes to rural areas. It is important to highlight the fact that in certain situations in agriculture, the speed of reaction is of crucial importance. That is why it is extremely important to establish mechanisms that will enable fast and high-quality processing and forwarding of data. Since broadband internet is often unavailable or insufficiently reliable in agricultural farms, it is necessary to establish mechanisms that will enable the high-quality application of modern information technologies in such working conditions. That is why Edge computing and Fog computing are extremely important (Kalyani, Collier, 2021.). The task of collecting data from IoT devices is performed over a local network by implementing various technologies. The application of information and communication technologies can be called by one name - smart agriculture. Smart devices collect the necessary data or react to given commands, but they should also be used in an adequate way. Application of modern information and communication technologies and devices through Cloud computing, Fog and Edge computing provides greater safety, security and efficiency in agriculture and rural development.

## Conclusion

Research in the work, through the analysis of current trends and parameters, summarized in table 6, indicates advantages in the application of innovations and information and communication technologies. At the same time, research points to numerous challenges that need to be overcome in rural areas in Serbia in this area. The application of new information and communication technologies and the digitization of the agricultural sector represent a great potential for improving rural development through increasing productivity, sustainability and competitiveness. Modern communication approaches and technologies, from artificial intelligence and robotics to the Internet of Things (IoT), can provide significant support and assistance to farms and businesses. Thanks to the application of innovative information and communication technologies and digitization, agricultural farms and businesses can benefit from a simpler value chain, with closer cooperation and better communication between producers, processors, distributors and traders. In addition to numerous advantages provided by the application of modern innovative information and communication technologies and digitalization, there is a legitimate threat that a digital gap can be created between those who have access to and actively use modern communication technologies and those without them.

**Table 6.** Advantages and challenges of digitization

<b>Advantages</b>	<b>Challenges</b>
<p><b>Greater economic performance</b></p> <ul style="list-style-type: none"> <li>- more effective decision-making</li> <li>- business optimization</li> <li>- increasing productivity and profit</li> <li>- sustainability of the agricultural sector</li> </ul>	<p><b>Connection</b></p> <ul style="list-style-type: none"> <li>- rural areas don't have reliable internet access</li> <li>- high price internet access</li> <li>-difficult introduction of digital technologies</li> </ul>
<p><b>Environmental sustainability and ecological efficiency</b></p> <ul style="list-style-type: none"> <li>-waste reduction using precision agriculture techniques</li> <li>- reducing pollution</li> </ul>	<p><b>Limited awareness of advantages and benefits</b></p> <ul style="list-style-type: none"> <li>- insufficient conscience about possibilities and benefits of applying technology</li> <li>- underdeveloped skills of human resources</li> <li>- lack of resources for the application of technologies</li> </ul>
<p><b>Competitiveness</b></p> <ul style="list-style-type: none"> <li>- increasing competitiveness</li> <li>- innovative solutions</li> <li>- creation of new business opportunities</li> </ul>	<p><b>System interoperability</b></p> <ul style="list-style-type: none"> <li>-different digital platforms that are not compatible, it makes difficult to exchange data and integrate different applications</li> </ul>

<b>Advantages</b>	<b>Challenges</b>
<b>Improvement of working conditions</b> - reduction of physical and mental burden on human resources in agriculture through automation and optimization of digital technology operations	<b>Human resources skills for using communication technologies</b> - low level of training and protectionism – protection of privacy and ownership of data, which hinders the exchange of data
<b>Greater supply chain transparency</b> - greater awareness of agricultural products - improved transparency of agricultural products	<b>Expenses</b> -high costs of introducing new technologies - the potential benefit cannot be paid off in the short term

Source: Autors based on EU digital strategy 2022.

Therefore, it is necessary to focus more attention on solving existing challenges in terms of creating reliable access to modern communication technologies, strengthening resources for the application of technologies, raising awareness, developing skills and training human resources in rural areas. In order to ensure the wide availability, application and inclusion of information and communication technologies and digitalization, it is important that the competent state authorities, through the adoption of incentive policies, leaders in the industry, as well as providers of technological services cooperate and place special emphasis on promoting the advantages of using innovative technologies and digitalization . Special emphasis should be placed on encouraging human resources in agriculture to train and adopt new technologies. In this way, the agricultural sector can effectively use the benefits of innovation, which directly affects greater profitability and sustainable development.

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