DIGITAL TECHNOLOGY IN AGRICULTURE: EVIDENCE FROM FARMS ON THE TERRITORY OF AP VOJVODINA

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ABSTRACT

Agricultural and rural development is a very current issue in the world. Today, agriculture is expected to meet the growing demands for the production of a sufficient amount of food. So, it is necessary to increase productivity in agriculture, while taking into account the long-term agricultural sustainability. The implementation of digitalization in agriculture leads to increased productivity, enables the growth of agricultural producers' profits and maintenance of food security. The aim of the paper is to analyze the application of digitalization in agriculture on farms in AP Vojvodina. In the paper 46 farms from the territory of AP Vojvodina were surveyed as part of the research. The results of the research showed that digital technology is still not used enough on farms in AP Vojvodina, and the main limiting factors are financial resources, education and lack of different types of training.

Introduction

Today, agriculture is facing numerous challenges and global changes. In the future, according to the UN's scenario, the growing population will reach 9.5 billion people in 2050 (FAO, 2018a) which must be fed while adapting to a context of increasing

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devastation: climate change, collapse of biodiversity, reduction of resources (soil, fresh water, phosphorus). Agriculture nowadays must accelerate changes to implement production systems that are more respectful of animal welfare and reduce its impact on the environment (reduction of the use of inputs such as fertilisers, pesticides, sustainable use of natural resources such as soil, water, reduction of greenhouse gas emissions) and contribute to the preservation of biodiversity (Bellon Maurel, Brossard, Garcia, Mitton, Termier, 2022).

Although agricultural production is currently sufficient to feed the world, 821 million people still suffer from hunger, and processes such as rapid urbanization have important implications for food production and consumption patterns (FAO, 2018b). The agri-food sector is still critical for livelihoods and employment, as there are more than 570 million small farms worldwide, and agriculture and food production make up 28% of the total global workforce (Lovder, Skoet, Ranei, 2016). Therefore, achieving the UN Sustainable Development Goal of 'a world without hunger' by 2030 will require more productive, efficient, sustainable, inclusive and resilient food systems, and this will require transformation of the current agricultural and food system (Trendov, Varas, Zeng, 2019).

In order to feed everyone without compromising the entire ecosystem and achieve food security, it is urgent to intervene by redesigning an efficient and sustainable food production system (Stankov & Roganović, 2022). Rolandi, Brunori, Bacco, Scotti, 2021). Nowadays many rural communities are faced with numerous problems. They have difficulty in reaching markets, there is a lack of public and health services, and depopulation is present which negatively affects sustainable food production. Bearing in mind these challenges implementation of digitalization in agriculture can contribute to both agriculture (through efficient use of resources) and rural communities (through the establishment of new services) (OECD, 2019; WEF, 2018). Also, implementation of digitalization in agriculture can contribute to achieving the UN Sustainable Development Goals (SDGs) in rural areas, such as "no poverty", "zero hunger", and "climate action" (FAO, 2018a; Campbell, Hansen, Rioux, Stirling, Twomlow, Wollenberg, 2018; Pantić et al., 2022). Sustainable food production system is crucial for achieving food security, especially nowadays in crisis situations.

The Republic of Serbia has very favorable conditions for the development of various types of agricultural production, and in terms of the volume and structure of available agricultural land, 0.7 hectares of agricultural land, i.e. 0.46 hectares of arable land per person (Ministry of Agriculture, Forestry and Water Management of Serbia, 2014). There are a large number of small family farms which are of great importance. However, small family farms don't have adequate support from the state. The size of farm is crucial for the efficiency of operations in agriculture, so with unfavorable size of farms it is hard to be competitive in the market and in terms of increased competition (Munćan, Todorović, Munćan, 2014). In the Republic of Serbia, small farms with fragmented land have high production costs and inefficient use of resources. Also, farms in Serbia have a low level of technical and technological equipment, small number of livestock per unit of agricultural

land and insufficient financial resources which makes it difficult to increase productivity in production. Therefore, such low productivity in production negatively affects the price competitiveness of production and puts the average agricultural producer in a difficult position on the market (Milovanović et al., 2022: Nestorov-Bizonj, Kovljenić, Erdelji, 2015; Ilić et al., 2022; Popović, Kovljenić, 2017).

In order for farms in the Republic of Serbia to survive in market competition, it is necessary for them to adopt new digital technologies that would enable them to increase their productivity, manage resources sustainably and achieve food security. Therefore, the aim of the paper is to analyze the application of digitalization in agriculture on farms in AP Vojvodina.

Literature Review

Part of the solution to achieving greater production and food security in the future may be the use of digital innovation and technology. Several sectors are rapidly transforming under the influence of the so-called "Fourth Industrial Revolution" (Industry 4.0) such as blockchain, Internet of Things and artificial intelligence (Trendov, Varas, Zeng, 2019).

As a consequence of the spread of mobile technologies, remote sensing and computing services in the agriculture and food sector there is an increase access to information, inputs, markets, finance by small farmers. Digital technologies are creating new opportunities to integrate small farmers into a digitally driven agri-food system (USAID, 2018) and the next period of growth in mobile connections is expected to come mainly from rural communities. Already, 70% of the poorest 20% in developing countries have access to mobile phones, and more than 40% of the world's population has access to the Internet (World Bank, 2016). So, nowadays there are major initiatives to increase the use of digital technologies by small farmers of developing countries.

Large number of authors dealt with issues of digitalization in agriculture and the benefits and limitations of its application. However there are not enough research that deal with the application of digital technology on farms in AP Vojvodina. Franklyn & Tukur (2012) have concluded that numerous factors could influence adoption of digitalization in agriculture and use in agricultural organizations, such as access to IT, demographic, IT training/education, trust, and time. Jurjević, Bogićević, Đokić, & Matkovski (2019) analyzed a set of indicators of economic, ecological and social sustainability and their connection with the implementation of information technologies in agriculture of Serbia. Their results of the research have shown that the application of information technologies in Serbia's agriculture is modest, compared to EU countries. This is due to the unfavorable educational structure of agricultural producers, and limited financial resources, which significantly affect the implementation of IT. Lakota, Stajnko, Vindiš, Berk, Kelc & Rakun (2019) analyzed the use of digital technology in Slovenian agriculture and they concluded that user-friendly and accessible technology is necessary for achieving food security. Salemink, Strijker, & Bosworth (2017) observed that initiatives to promote digitalization in rural contexts are mainly based on a free-market rationale without

considering contextual specificities (e.g., digital skill levels, private investments, and trust in technology). Rotz et al. (2019) state that automatized agriculture significantly improves the lives of farmers and workers who can utilize digital technologies, creating new job opportunities, but also a radically bifurcated labor market increasing social asymmetries. Rolandi, Brunori, Bacco & Scotti (2021) state that digitalization may reduce costs for farms, environmental impact of agricultural production, improve crop yields, and farmers' income. They also state that there is a risk that these improvements will only occur for farmers in high-income countries.

Farms in the Republic of Serbia are characterized by the fragmentation of farms, large number of small family farms, unfavorable age structure of farmers, outdated machinery with traditional production technology, low purchase prices, problems with the marketing of agricultural products, underdeveloped cooperatives, insufficient subsidies, outdated plantations, as well as small number of conditional livestock fund (Ristić, Knežević, Bošković, 2020). Also, these farms constitute the majority of the total structure (Census of Agriculture, 2012). In the agricultural sector of Serbia, the application of digital technology is at a low level, compared to highly developed countries. There are numerous factors that limit the use of digital technology, but one of the important limiting factors is the inadequate educational structure of farmers. Mostly large farms, which are market-oriented, invest significantly in new technologies, because it is necessary to respond appropriately to rapid changes in market liberalization and increased foreign competition (Jurjević, Bogićević, Đokić, Matkovski, 2019).

Observed according to the average arable land by farm, the Vojvodina Region has the most average arable land 12.39 ha, Serbia North 10.94 ha, Belgrade Region 4.84 ha, Serbia South 4.31 ha (Statistical Office of the Republic of Serbia, 2022). As farms in Vojvodina are larger farms, it can be concluded that this region is particularly suitable for the adoption of digital technology, because mostly large farms invest in new technologies.

The adoption of modern approaches, concepts and models in agriculture of the Republic of Serbia requires a realistic assessment of the resource potential and limitations for each development option individually. An assessment is especially needed for each local community and, if necessary, for each farm. However, although there are opportunities for the introduction of certain innovations, they may prove to be unacceptable, if apart from economic benefits, they do not provide other necessary benefits, such as socio-cultural, ecological, health or institutional (Ristić, Knežević, Bošković, 2020).

Bearing in mind the above, the introduction of new approaches and modern digital technologies in agriculture must be accompanied by appropriate activities of competent institutions, with the establishment of partnerships for rural development, the preparation of local strategies for agricultural and rural development and the adoption of other necessary documents. Good preparation for the use of EU pre-accession funds intended for agriculture and rural development, in the process of accreditation of new IPARD measures (Instrument for Pre-Accession Assistance in Rural Development), is important for the Republic of Serbia. Therefore, it is necessary that the national program

for agriculture and rural development for the period 2022-2024 be complementary to the IPARD III program. Serbia should accelerate the implementation of an integrated management and control system (IACS), the transition from manual to electronic processing of requests, separation of payments from production and the connection of area payments with established standards. The Farm Accounting Data System (FADN) has been established, but its sample size and data quality need to be further improved to be fully representative (EC, 2022).

It is also of great importance to follow the Common Agricultural Policy of the EU - CAP (Common Agricultural Policy) for the latest program period, 2021-2027. year, with projections of the EU market for food and beverages until 2030. Projections in the field of food are significant planning of production intended for export and maintenance of food security. The OECD-FAO forecasts for the period 2019-2028 should also be taken into account, especially when it comes to food prices, production, expected consumption and trade in the world. Therefore, it is necessary to monitor the future projections of international organizations and institutions in this area, as well as technological changes relevant to the agricultural sector and the rural economy (Ristić, Knežević, Bošković, 2020).

Materials and Methods

As part of the research, a survey was conducted on 46 representative farms from the territory of AP Vojvodina. The research instrument was a questionnaire, which was created for the purposes of this research. The first part of the questionnaire covered the general questions about the surveyed members of the agricultural holdings, and the second part covered the questions about the application of digital technology in agriculture.

Empirical research consisted of a questionnaire prepared for members of agricultural farms and data was collected by visiting agricultural farms, surveying at fairs and similar events on the territory of the APV where members of agricultural farms gather or by submitting their filled questionnaires to provided e-mails addresses.

The data were analyzed qualitatively, i.e. through the analysis of the frequency of respondents' answers, i.e. using descriptive statistics. It is especially pointed out that even if complex statistics were not implemented, the paper importance is reflected in the subject and the covered sample of research (scope, structure and distribution).

Results of research

In the continuation of the paper, the frequencies of respondents' answers to the questions about the application of digital technology in agriculture are presented.

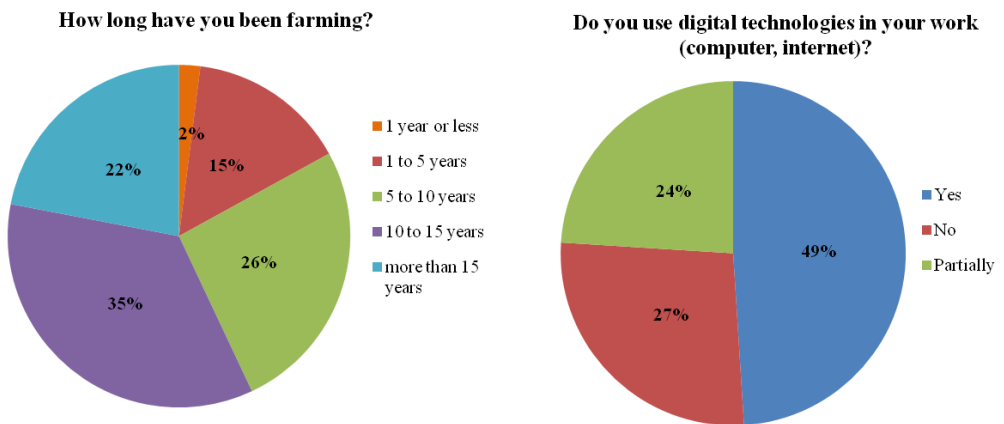**Figure 1**. Basic characteristics of the sample
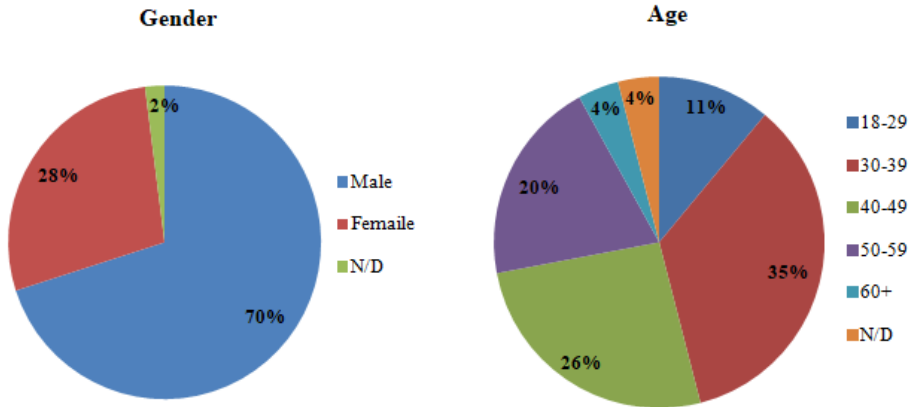
*N/D unanswered questions

Source: Author based on the conducted research

Based on *Figure 1*, the research results showed that the majority of farm respondents are men (men 70%; women 28%) and that the majority of respondents are aged 30-39 (35%).

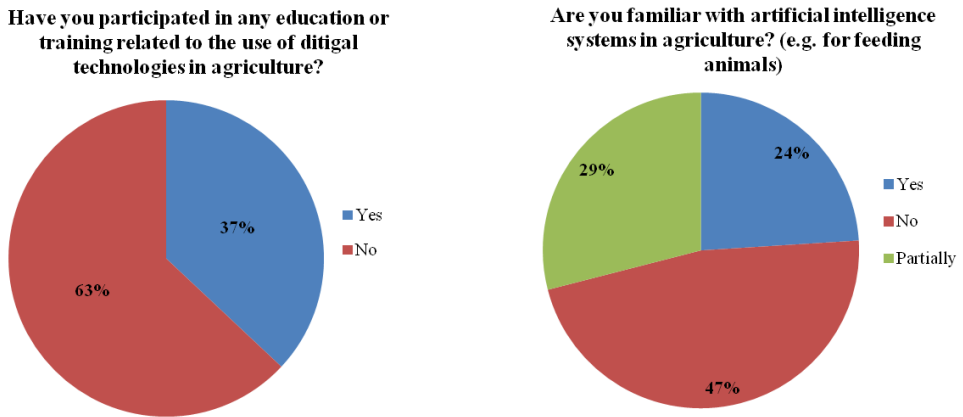**Figure 2.** Use of digital technology in agriculture

*N/D unanswered questions

Source: Author based on the conducted research

Regarding the application of digital technology (*Figure 2*), the results showed that large number of respondents have been engaged in agriculture for 10 to 15 years, and a greater number of them use digital technology (49%).

**Figure 3**. Education about digital technology in agriculture

Have you participated in any education or training related to the use of ditigal technologies in agriculture?

Are you familiar with artificial intelligence systems in agriculture? (e.g. for feeding animals)

*N/D unanswered questions

Source: Author based on the conducted research

Figure 3 shows that the majority of respondents (63%) did not have education or training related to the use of digital technology in agriculture and a large number of respondents (47%) are not familiar with the application of artificial intelligence in agriculture.

Figure 4. Do you think that the government/state provides sufficient support for the application of digital technologies in agriculture? (e.g. financial support, availability of training, etc.)
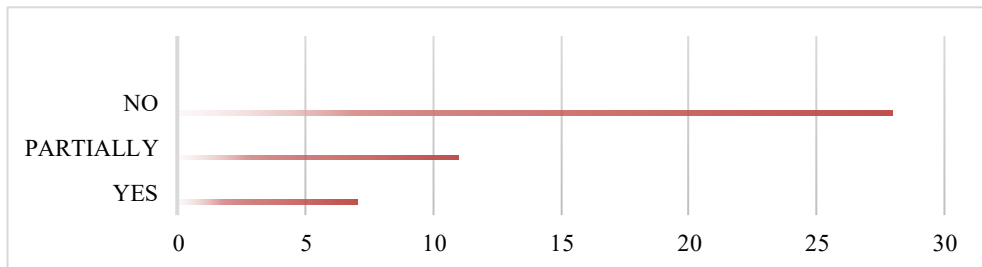
Source: Author based on the conducted research

Figure 4 shows that the majority of respondents (28 respondents) think that government/ state does not provide sufficient support for the application of digital technologies in agriculture (e.g. financial support, availability of training, etc.).
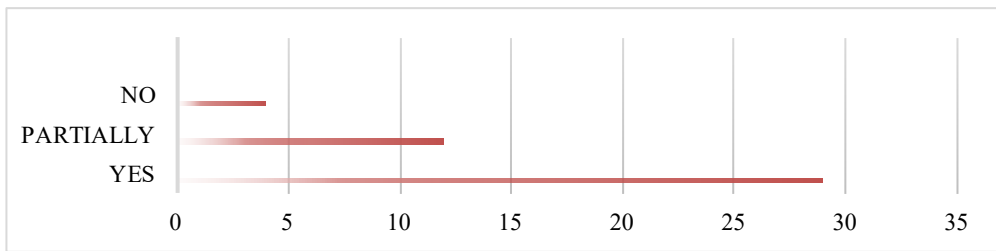
Figure 5. Do you think that rural environment is one of the obstacles for the use of digital technologies in your work?
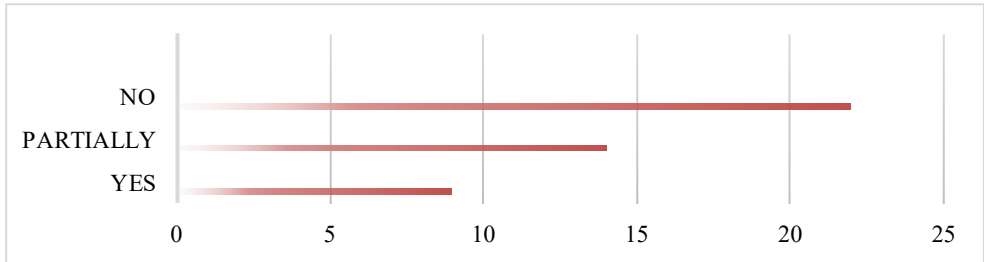
Source: Author based on the conducted research

Figure 5 shows that the majority of respondents (22 respondents) think that rural environment is not one of the obstacles for the use of digital technologies in their work.

Figure 6. Have you had the opportunity to collaborate with other farmers who use digital technologies in their work?

Source: Author based on the conducted research

Regarding the opportunity to collaborate with other farmers *Figure 6* shows that the majority of respondents (29 respondents) have had the opportunity to collaborate with other farmers who use digital technologies in their work.

Figure 7. What do you need to introduce digital technologies in your work?
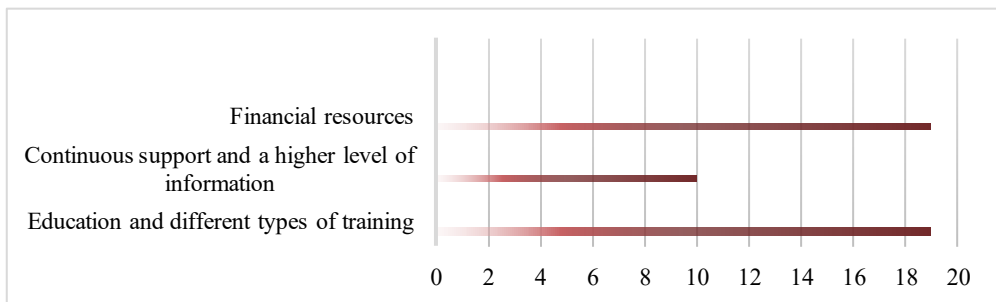
Source: Author based on the conducted research

Figure 7 shows that the same number of respondents (19 respondents) believe that financial resources and education and different types of training are needed in order to introduce digital technology into their work, while 10 respondents believe that continuous support and a higher level of information are needed in order to introduce digital technology into their work.

Discussion

The results of the conducted research showed the following:

- The majority of surveyed are male and belong to the population of working age (15-64 years old).

- The largest number of participants have been working in agriculture between 10 and 15 years, and over 80% for more than 5 years.

- The vast majority had the opportunity to cooperate with farmers who use digital technologies in their work.

- According to the results, rural environment is generally not one of the obstacles for the adoption of digital technologies.

- The opinion of the majority is that the government/state does not provide sufficient support for the application of digital technologies in agriculture.

- Most of surveyed use digital technologies (almost 50% - yes, 24% - partially), but 63% did not participate in education or training related to the adoption of digital technologies in agriculture.

- Almost 50% of participants are not familiar with artificial intelligence systems in agriculture (30% partially); they mostly do not know that the Institute for Artificial Intelligence was founded in the RS, so they are not sure whether the Institute's activities will be extended to agriculture.

- Fundings, education and various types of training are needed to use digital technologies.

The results of the research showed that the majority of farms from the territory of Vojvodina have been engaged in agriculture for many years (more than 10 years) and have had the opportunity to cooperate with farmers who apply digital technology. In this way, they are familiar with the benefits of applying this technology. However, the respondents are still not familiar with artificial intelligence systems in agriculture, which in today's business conditions have shown significant positive results during its application. Likewise, since larger farms are ready to adopt new digital technologies, the region of Vojvodina has the largest areas of arable land, so this region is particularly suitable for the application of digital technology in agriculture.

The results of the conducted research showed that less than 50% of respondents use digital technology and they are not familiar with the application of new technologies in agriculture. Also, results of the conducted research showed that more than 50%

did not have education or training related to the application of digital technology in agriculture. According to the surveyed respondents, the main limiting factors for the use of digital technology in agriculture are financial resources, education and different types of training. The importance of training/education and investments for the application of digital technology in agriculture is also confirmed in the papers Franklyn & Tukur (2012), Jurjević, Bogićević, Đokić, & Matkovski (2019) and Salemink, Strijker, & Bosworth (2017).

So, in order to resist future challenges and maintain an appropriate level of food security in Serbia, it is necessary to adopt digital technology in agriculture. Today the level of agricultural production depends on the availability of modern digital technologies of the new generation. Therefore, the transition to advanced intelligent technologies is the main vector for the improvement of agricultural production, which ensures an increase in production efficiency, an increase in productivity and quality of work, optimization of production costs and reduction of their losses (Marinchenko, 2021).

As specified, digital technologies provide numerous benefits, but there are also obstacles to the adoption of digital technologies in agriculture. Some of the main obstacles are high investment costs and a lack of education, training and advisory services for farmers, especially small and medium-sized farmers (Paustian and Theuvsen 2017; Rose and Chilvers 2018) and therefore, it is necessary to create appropriate policies that can help overcome these obstacles. By offering financial assistance to farmers in the form of tax credits and/or subsidies, short-term opportunity costs and long-term financial risks associated with technological innovation and investment would be compensated (Ehlers, Huber, Finger, 2021). Also, it is stated in the Farm to Fork Strategy (F2F), that providing agricultural training and advisory services could encourage greater application of digital technologies on farms. Therefore, it is necessary that there is a merger of advisory services with different forms of financial incentives which will increase application of digital technology. At the same time, these types of measures can help to avoid the digital divide between large and small farmers in the future (Mac Pherson, Voglhuber-Slavinsky, Olbrisch, Schöbel, Dönitz, Mouratiadou, Helming, 2022).

Conducted research is a pilot project and as such it presents a basis for future research which would include both larger number of agricultural producers and more different variables. We expect that concrete further steps that should be taken would be distinguish and thus contribute not just improvement of the digital literacy of the members of agricultural farms/producers, but also green and digital agriculture in general.

Conclusion

In AP Vojvodina, agriculture is of great social and economic importance, especially in emergency situations. In order to resist future challenges and maintain an adequate level of food security, it is necessary to invest in the agriculture development of the Republic of Serbia. However, agriculture development in modern conditions is a very complex

process and it is very difficult to make precise predictions in this area. Agriculture development is influenced by a number of economic-financial, legal-political, socio-cultural, as well as environmental and health-safety factors.

So, there needs to be efficient use of available resources, as well as encouraging those products and activities within the rural economy which have shown success in the market and are examples of good practice. Encouraging young people to engage in agricultural activities of the rural economy is necessary, with a more intensive introduction of modern technologies in agricultural practice and life in the countryside. The future agricultural development of the AP Vojvodina is significantly under the influence of internal factors and depends on the adoption of new digital technologies, adequate strategic directions of development, their implementation and the direct involvement of key actors.

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Conflict of interests

The authors declare no conflict of interest.

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