THE USE OF INFORMATION TECHNOLOGIES AND IMPLEMENTING BIG DATA CONCEPT, DRONES, AND ARTIFICIAL INTELLIGENCE IN THE AGRICULTURE - PERCEPTION OF SMALL FARMERS IN SERBIA

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A B S T R A C T

This study explores the attitudes and readiness of small farmers in the Republic of Serbia toward digital transformation in agricultural production, with emphasis on the application of Big Data, drone technology, and artificial intelligence. The research implemented a quantitative survey, collecting data from 437 participants across three regions of Serbia. Descriptive statistics and Spearman's rank correlation analysis were used to examine the correlation of demographic factors, including age, gender, education level, and geographic location, with the perceptions on using information technologies in agriculture. Results present significant interest in digital tools that support productivity and sustainability, despite limited practical experience and low levels of digital literacy. Statistically significant correlations were identified between age, education level, and geography in shaping openness toward technological adoption, while gender showed no significant correlation. Younger and more educated respondents consistently expressed stronger support for using advanced technologies, underscoring the importance of strategic government awareness programs and training initiatives.

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Introduction

With the rapid growth of global population, the demand for food is rising rapidly, too. To meet this increasing need, 21st century agriculture must adopt innovative technologies and approaches that enhance productivity, sustainability, and resilience (Zhang, Guo, Ullah, Melagraki, Afantitis, & Lynch, 2021; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022; Uzhinskiy, 2023; Gebresenbet, Bosona, Patterson, Persson, Fischer, Mandaluniz, … Nasirahmadi, 2023; Guebsi, Mami, & Chokmani, 2024; Boros, Szólik, Desalegn, & Tőzsér, 2025).

In the Republic of Serbia, agriculture is one of the most important sectors of economy. However, it faces challenges such as outdated practices, dominance of small farms with limited access to modern technologies (Đurić, Cvijanović, Prodanović, Čavlin, Kuzman, & Lukač Bulatović, 2019). Most of the current research on Serbia focuses on the possibilities of satisfying growing demands for quality food while aligning with EU agricultural standards (Stojiljković, Raičević, & Djurković, 2025). New topics emerging from both academic research and practice, concentrate on implementation of and investments in innovative, advanced technological solutions that would improve agricultural production efficiency and minimize potential negative impact on the environment (Bešić, Ćoćaklo, Bakator, Vidas-Bubanja, & Stanisavljev, 2025). This is particularly important for small producers, who often lack access to new technologies and necessary trainings for their importance and use. In this process emerges the crucial role of the state in creating conditions for the use of new technologies and systemic organization of trainings for small producers.

Literature review

Over the past decade, a growing body of research has focused on the application of emerging technologies in agriculture, with particular emphasis on information technology, Big Data, Internet of Things (IoT), artificial intelligence (AI), machine learning, deep learning, and the use of Unmanned Aircraft Systems (UAS) or drones (Bu, & Wang, 2019; Rađenović, Krstić, & Marković, 2020; Boursianis, Papadopoulou, Diamantoulakis, Liopa-Tsakalidi, Barouchas, Salahas, G., … Goudos, 2022; Schaefer, 2023; Fuentes-Peñailillo, Gutter, Vega, & Silva, 2024). Widely researched concept of Industry 4.0 (Javaid, Haleem, Singh, & Suman, 2022) can also be implemented in agriculture. Current body of research focuses not only on developed countries (Mohr, & Kühl, 2021), but on developing countries, too, where new technological solutions can assist in improvement of agricultural practices (Ilic-Kosanovic, Pazun, Langovic, & Tomic, 2019).

Rising global temperatures and the increasing frequency of extreme weather events, such as severe droughts and torrential rains pose mounting challenges to agricultural productivity. To address these issues, innovative solutions including AI, Big Data analytics, and IoT, are becoming essential tools in optimizing crop yields and ensuring sustainable agricultural practices (Petkovic, Petkovic, & Petkovic, 2017; Linaza, Posada, Bund, Eisert, Quartulli, Döllner, Pagani, Olaizola, Barriguinha, Moysiadis, & Lucat, 2021; Pantović et al., 2022; Ahmed, & Shakoor, 2025).

Some researchers are focused on the use of AI, especially smart sensing systems, in crops' spraying control in order to avoid contamination, (Partel, Costa, & Ampatzidis, 2021). Those systems are also used for identification of weed, assessing crops, fruit, and vegetables quality, for timely detection of diseases, and for minimizing waste (Costa, Nunes, & Ampatzidis, 2020). AI can also support crop monitoring (in terms of quality, soil evaluation, yield, etc.) (Roslim, Juraimi, Che'Ya, Sulaiman, Manaf, Ramli, & Motmainna, 2021; Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Arza-García, & Burgess, 2023; Näsi, Mikkola, Honkavaara, Koivumäki, Oliveira, Peltonen-Sainio,... & Alakukku, 2023). Since the use of fertilizers and pesticides endangers the environment, the need for the use of new technologies to minimize the negative effect of excess chemicals is one of the essential topics for researchers and practicioners alike (Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022). In response to these concerns, many scholars and experts are now exploring data-driven methods such as precision farming and remote sensing to enhance crop management while safeguarding soil health and biodiversity (Talaviya, Shah, Patel, Yagnik, & Shah, 2020; Bešić et al., 2024).

Drone technology is used for crop monitoring, precision weed and pest control and mapping, and evaluation of possibilities for development of various diseases (Drăgoi et al., 2018; Michels, von Hobe, Weller von Ahlefeld, et al. 2021; Rejeb, Abdollahi, Rejeb, & Treiblmaier, 2022; Spanaki, Karafili, Sivarajah, Despoudi, & Irani, 2022; Erokhin et al., 2022; Uzhinskiy, 2023). In the agricultural sector, drone manufacturers are designing customized, application-oriented solutions tailored to the specific needs of farmers and agronomists. Technological developments have led to the development of a wide range of UAV models in various sizes, weights, and configurations, each capable of carrying specialized sensor payloads (Merz, Pedro, Skliros, Bergenhem, Himanka, Houge, Matos-Carvalho, Lundkvist, Cürüklü, Hamrén, Ameri, Ahlberg, & Johansen, 2022; Radic, Radić, & Cogoljević, 2022; Guebsi, Mami, & Chokmani, 2024). These innovations enable precision farming applications such as crop health monitoring, soil analysis, irrigation management, and yield forecasting, making agriculture more efficient and data driven (van der Merwe, Burchfield, Witt, Price, & Sharda, 2020; del Cerro, Cruz Ulloa, Barrientos, & de León Rivas, 2021; Abbas, Zhang, Zheng, Alami, Alrefaei, Abbas,... & Zhou, 2023; Uzhinskiy, 2023; Phang, Chiang, Happonen, & Chang, 2023).

One of the significant topics for researchers is the use of AI in land irrigation. IoT, for example, enables solar power based irrigation systems (Ahmed, & Shakoor, 2025). One of the new, technology based, methods is drip irrigation, with minimum of water used for maximum gains (Talaviya, Shah, Patel, Yagnik, & Shah, 2020). AI can also be used for enabling the preservation of environment during the process of agricultural production (Oliveira, & Silva, 2023). In addition, the new technologies, namely AI, measure rainfall and predict extreme weather conditions (severe rain, floods, or draughts) (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025; Ahmed, & Shakoor, 2025).

One of the significant roles of AI lays in its application in decision-making process of farmers (Alaoui, Amraoui, Masmoudi, Ettouhami, & Rouchdi, 2024; Backman, Koistinen, & Ronkainen, 2023; Gebresenbet, Bosona, Patterson, Persson, Fischer, Mandaluniz, Nasirahmadi, 2023; Milačić, 2024; Javaid, Haleem, Haleem Khan, & Suman, 2023). Big data enables precision agriculture by integrating real-time sensor data, satellite imagery, and environmental variables to optimize irrigation, fertilization, and crop protection decisions and assists in statistical analysis of available data (Delgado, Short Jr, Roberts, & Vandenberg, 2019; Ahmed, & Shakoor, 2025). AI also has key role in product storing, marketing, product placing, demand forecasting, and prices projecting (Javaid, Haleem, Haleem Khan, & Suman, 2023). Furthermore, Big Data supports predictive modeling and supply chain optimization, allowing farmers to anticipate risks, manage resources more efficiently, and align production with market demands (Delgado, Short Jr, Roberts, & Vandenberg, 2019)

Some of the other key topics include ecological issues and the impact on society and ethical behavior in production and consumption (Klerkx, Rose, 2020). Some authors focus on the risks of the cost and attainability of modern technologies for small farmers, not only in developing countries, but in developed countries as well. The trend of introducing and implementing new technologies can lead to destruction of small farmers and the further rise of corporate landholdings (Klerkx, & Rose, 2020). Some of the prerequisites for implementing information technologies are stable Internet connection, and data processing capability, which is not always available in rural areas (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025).

Finally, one of the most important issues in introducing new technologies, especially to the small farmers is resistance from farmers, lack of understanding of the possible gains, inadequate education, and training for using various new technological solutions (Meshram, Patil, Meshram, Hanchate, & Ramkteke, 2021). Some of the skills needed are highly specialized and technical (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025), for example for drone operating, and other, traditional, are becoming obsolete. Governments' initiatives are needed for developing awareness and training programs (Aijaz, Lan, Raza, Yaqub, Iqbal, & Pathan, 2025), and providing accessible and inexpensive solutions, that can be shared through communities.

In the Republic of Serbia, implementation of digital technologies in agricultural practices is not a new process, it is particularly evident in the northern Serbian region of Vojvodina, where their application has led to significant advances in productivity. Agricultural producers in Vojvodina benefit from fertile land and more advanced infrastructure, resulting in higher productivity compared to those in central and southern Serbia. In contrast, producers in southern Serbia face various disadvantages, including mountainous terrain, limited access to technology, and lower education levels (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021). However, despite increasing understanding of the strategic importance of using IT for achieving sustainable agricultural production, Serbia continues to face many barriers for broader information technologies adoption in agricultural practices. These include limited financial resources and, especially, a generally low level of digital literacy and capacity for innovations among agricultural producers (Jurjević, Bogićević, Đokić, & Matkovski 2019; Kljajić, Paraušić, & Stanković, 2024; Paunović, Štrbac, & Živković, 2024). Despite these obstacles, integrating IT into Serbian agriculture is seen as a strategic pathway toward long-term sustainability, economic competitiveness, and alignment with European Union standards (Vukadinovic, Jesic, Okanovic, & Lovre, 2022; Stojiljković, Raičević, & Djurković, 2025), and this process requires state strategic support.

Materials and methods

The purpose of the empirical research is to analyze the perceptions of agricultural producers of three distinct areas: in central Serbia - Raška district, municipality Kraljevo, villages Lazac and Samaila; in northern, Autonomous Province of Vojvodina - Suthern Bačka district, municipality Vrbas, villages Savino selo and Ravno selo; and in the furthermost south of the country in Pčinjski district - municipality Vranje, villages Ćukovac and Tibudže, on the use of information technologies and implementing Big Data, drones, and artificial intelligence in the agriculture.

The neighbouring villages Samaila and Lazac are located between towns Kraljevo and Čačak in central Serbia and they belong to the municipality of Kraljevo. While Samaila is positioned mostly in the flat land, Lazac is spreading across mainly hilly area. Samaila covers 23.33 km^2, and Lazac 21.75 km$^{2.}$ (Municipality of Kraljevo, 2017). As of population survey from 2011, Samaila consists of 485 households and 1466 inhabitants and Lazac consists of 249 households and 695 inhabitants (Municipality of Kraljevo, 2017; Republički zavod za statistiku, 2011). Villages Savino selo and Ravno selo are located on the west from town of Vrbas in a flat land and they belong to the municipality of Vrbas. Savino selo consists of 939 households and 2957 total inhabitants, and Ravno selo consists of 1014 households, 3107 total inhabitants as of survey from 2011 (Vrbas, 2020; Republički zavod za statistiku, 2011). Villages Ćukovac and Tibudže are located south-east of the town of Vranje, and they belong to the municipality of Vranje. Ćukovac consists of 285 households and 1030 inhabitants and Tibudže consists of 368 households and 1295 inhabitants (Republički zavod za statistiku, 2011).

The study included 437 adult respondents over age of eighteen that have been fully or partially involved in agricultural production. The survey in Raška regions villages has been conducted in July/August 2024, in Vojvodina villages in October/November 2024, and in the Pčinjska region villages in January 2024, through Google forms platform, that the respondents could fill themselves or the volunteers could have helped the older ones to fill in the forms on the tablets.

In the first part of the structured survey, the participants have had the opportunity to state their knowledge of the term e-agriculture, strategy of agricultural development in the EU, of using apps for marketing and sales for maximizing the profit, and the acquaintance with the usage of Cloud, drones, sensors and IoT systems for crops monitoring. In the second part of the survey, four main research questions have been devised in regard to their perception on the use of information technologies and implementing Big Data, drones, and artificial intelligence in the agriculture.

According to the literature review, four main research questions (statements) were developed:

- It is necessary that the state, faculties, and other certified educational institutions provide online or live courses for the agricultural producers on the benefits and the importance of new information technologies usage in agricultural production.
- If the state enables usage of Big Data concept for the purpose of production risk minimizing, I would participate in its implementation (courses, execution, etc.).
- I would use drones as agricultural tool (terrain surveying, crop dusting, soil monitoring, etc.).
- Robotization and artificial intelligence has the potential for agriculture in the Republic of Serbia in the near future.

Five-point Likert scale was used to assess the statements (1 – I disagree completely; 2 – I somewhat disagree; 3 – I am neutral; 4 – I somewhat agree; 5 – I agree completely). The constructed scale was subjected to the test of reliability and it had strong (0.875) Cronbach's Alpha value, which indicated an adequate level of internal consistency for the scale with the specific sample used for the study (Cohen, 1988) as it can be seen at Table 1.

Table 1. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.875	.877	4

Source: Authors

Furthermore, it was assessed weather the Cronbach's Alpha would suffer from the removal of some items and the results are presented at Table 2.

Table 2. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
RQ 1	9.23	8.013	.723	.537	.844
RQ 2	9.59	7.824	.765	.592	.828
RQ 3	9.25	7.737	.741	.551	.836
RQ 4	9.31	7.360	.706	.502	.853

Source: Authors

Collected data have been analyzed by using statistical package SPSS v. 18.

Results and discussion

The total sample size has been 497 and 17.6% of the participants have been from Lazac (n=77), 15.1% (n=66) from Samaila, 18.3% from Savino selo (n=80), 14.4% from Ravno selo (n=63), 19.7% from Ćukovac (n=65), and 14.9% from Tibudže (n=65). Among the participants, 49% have been female (n=214), and 51% male (n=223) as seen at Table 3.

Table 3. The respondents' village and gender

Village	Frequency	%	Gender	Frequency	%
Samaila	66	15.1	Male	223	51.0
Lazac	77	17.6	Female	214	49.0
Savino selo	80	18.3	Total	437	100.0
Ravno selo	63	14.4			
Čukovac	86	19.7			
Tibudže	65	14.9			
Total	437	100.0			

Source: Authors

The participants belonged into different age groups, as well as five levels of education, going from unfinished elementary education to higher education (college or university), as it can be seen at Table 4.

Table 4. The respondents' age and level of education

Respondents age (years)	Frequency	%	Highest educational level achieved	Frequency	%
From 18 to 25	23	5.3	Unfinished Elementary school	10	2.3
From 26 to 35	72	16.5	Elementary school	81	18.5
From 36 to 45	93	21.3	Vocational high school (three years)	172	39.4
From 46 to 55	90	20.6	High school	168	38.4
From 56 to 65	99	22.7	Higher education	6	1.4
Over 65	60	13.7	Total	437	
Total	437	100.0			

Source: Authors

The participants belonged in the households with various number of members and various number of members involved in the agriculture as seen at Table 5.

Table 5. Total number of household members and household members involved in agriculture

Total household members	Frequency	%	Household members involved in agriculture	Frequency	%
One	40	9.2	One	198	45.3
From 2 to 3	241	55.1	Two	181	41.4
From 4 to 5	122	27.9	Three	36	8.2
More than 5	34	7.8	Four	22	5.0
Total	437	100.0	Total	437	100.0

Source: Authors

Research results indicate that half of the surveyed participants (50.3%) are familiar with the concept of e-agriculture, suggesting a basic understanding and a genuine interest in the digital transformation of agricultural practices. On the other hand, a significant majority (86.3%) are unfamiliar with agricultural development strategies implemented across European countries, which points to a lack of knowledge and experience with international standards and innovations.

Similarly, most participants (68.2%) believe that mobile applications for marketing and sales have the potential to maximize profits in agriculture, emphasizing enthusiasm and openness toward using digital tools in the business dimension of farming. However, the vast majority have never used cloud-based services (91.5%) and lack familiarity with sensor technology and IoT systems for crop monitoring (82.4%), revealing a significant gap in practical knowledge and technological skills necessary for implementation of new technologies.

Considering everything, these findings suggest that agricultural producers in Serbia possess an initial awareness and motivation to engage with digital technologies, but are held back by insufficient knowledge, training, and learning opportunities. There is a clear need for systemic education and learning for enabling effective integration of digital innovations and ensuring sustainable agricultural development.

Finally, correlation analysis was conducted in order to determine correlation of demographic variables (age, gender, education and geographical position) to the attitudes on our research questions using Spearman rank order correlation coefficient.

As presented at Table 6, a statistically significant negative correlation was observed between age and the perceived necessity for institutional education on digital technologies in agriculture (*Spearman's* $\rho = -0.493$, $p < .01$), indicating that younger participants are more likely to recognize the importance of such training. Conversely, education level showed a significant positive correlation (*Spearman's* $\rho = 0.490$, $p < .01$), suggesting that individuals with higher educational level are more inclined to support initiatives for agricultural digital training.

In contrast, no statistically significant correlations were found for gender (*Spearman's ρ = 0.017, p = .726*) or geographic location (*Spearman's ρ = 0.056, p = .244*), implying that these factors do not substantially influence perceptions regarding the need for systemic education on information technology in agriculture.

Table 6. Correlations - The correlation of demographic variables to RQ1

			Age	Gender	Education	Village
Spearman's rho	It is necessary that the state, faculties, and other certified educational institutions provide online or live courses for the agricultural producers on the benefits and the importance of new information technologies usage in agricultural production.	Correlation Coefficient	-.493**	.017	.490**	.056
		Sig. (2-tailed)	.000	.726	.000	.244
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 7, a significant negative correlation was found between age and willingness to participate in the implementation of Big Data technologies in agriculture (*Spearman's ρ = -0.521, p < .01*), suggesting that younger participants are more inclined to engage with state-supported initiatives involving advanced digital tools for risk management. Conversely, education level exhibited a strong positive correlation (*Spearman's ρ = 0.600, p < .01*), indicating that participants with higher educational attainment are more likely to support and get involved in such programs.

Geographic location (village) revealed a small but significant negative correlation (*Spearman's ρ = -0.247, p < .01*), which may reflect regional differences in access, infrastructure, or exposure to digital agriculture practices. Meanwhile, no significant correlation was observed for gender (*Spearman's ρ = -0.005, p = .918*), implying that gender does not substantially influence attitudes toward participating in Big Data implementation in agriculture.

Table 7. Correlations - The correlation of demographic variables to RQ2

			Age	Gender	Education	Village
Spearman's rho	If the state enables usage of Big Data concept for the purpose of production risk minimizing, I would participate in its implementation (courses, execution, etc.).	Correlation Coefficient	-.521**	-.005	.600**	-.247**
		Sig. (2-tailed)	.000	.918	.000	.000
		N	437	437	437	437
**. Correlation is significant at the 0.01 level (2-tailed).						

As presented in Table 8, a significant negative correlation was observed between age and the willingness to use drones in agricultural applications such as terrain surveying, crop dusting, and soil monitoring (*Spearman's* $\rho = -0.506, p < .01$), indicating that younger participants are more inclined to adopt drone technologies in farming. Furthermore, education level demonstrated a strong positive correlation (*Spearman's* $\rho = 0.538, p < .01$), suggesting that individuals with higher educational attainment are more likely to engage with drone-based agricultural tools.

A small but significant negative correlation with geographic location (*Spearman's* $\rho = -0.155, p = .001$) implies that participants from more remote or rural areas may exhibit lower levels of enthusiasm or readiness to implement drone technology, possibly due to limited access or exposure. No statistically significant correlation was found for gender (*Spearman's* $\rho = -0.033, p = .488$), indicating that gender does not play a notable role in shaping attitudes toward the adoption of drone tools in agriculture.

Table 8. Correlations - The correlation of demographic variables to RQ3

			Age	Gender	Education	Village
Spearman's rho	I would use drones as agricultural tool (terrain surveying, crop dusting, soil monitoring, etc.).	Correlation Coefficient	-.506**	-.033	.538**	-.155**
		Sig. (2-tailed)	.000	.488	.000	.001
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

As indicated in Table 9, a moderate negative correlation was found between age and the belief in the potential of robotization and artificial intelligence (AI) in Serbian agriculture (*Spearman's* $\rho = -0.477, p < .01$), suggesting that younger participants are more optimistic about the adoption of these technologies in the near future. In parallel, a moderate positive correlation was observed with education level (*Spearman's* $\rho = 0.478, p < .01$), which implies that higher levels of formal education are associated with stronger support for integrating AI and robotics in agricultural practices.

Additionally, a small but statistically significant negative correlation with geographic location (village) was noted (*Spearman's* $\rho = -0.153, p = .001$), indicating that individuals from more remote or rural areas may be less convinced of the immediate significance or feasibility of such advanced technologies. No significant correlation with gender was detected (*Spearman's* $\rho = -0.020, p = .681$), suggesting that perceptions regarding AI and robotization are consistent across genders.

Table 9. Correlations - The correlation of demographic variables to RQ4

			Age	Gender	Education	Village
Spearman's rho	Robotization and artificial intelligence has the potential for agriculture in the Republic of Serbia in the near future.	Correlation Coefficient	-.477**	-.020	.478**	-.153**
		Sig. (2-tailed)	.000	.681	.000	.001
		N	437	437	437	437

**. Correlation is significant at the 0.01 level (2-tailed).

Findings from this study suggest that while many agricultural producers demonstrate genuine interest in innovative tools such as marketing apps, Big Data systems, drones, and AI, there is a significant gap between interest and abilities. Factors such as age, education level, and geographic location consistently correlate with the perceptions and willingness to adopt digital solutions, on the other hand gender appears largely neutral in its effect.

Significantly, the data indicates that younger and more educated farmers show evident openness toward digital transformation. Despite limited practical experience with advanced technologies like cloud services and IoT systems, a clear enthusiasm for learning is existing. Younger, educated farmers want to learn, but they need support through strategic policies and programs.

Discussion

As it is stated, the findings of this study present foundation for digital transformation in Serbian agriculture, especially when it comes to small farmers. While many small farmers, especially older ones, lack understanding and experience with advanced technologies such as cloud computing, IoT systems, and drones, many, especially younger and more educated ones, express a strong interest and willingness to learn and engage with digital innovations. Studies show that in other sectors, such as tourism, the use of information and communication technologies is largely determined by age and level of education (Langović, Pažun, Grujčić, Nikolić, Langović-Milićević & Ugrinov, 2025). Similarly, the use of ICT in agriculture has wider implications, as it has a positive impact on the economy, i.e. on the economic development and competitiveness of the sector (Pažun, Langović, Stojanović, Langović-Milićević & Božović, 2025). Previous research also emphasized the gap between motivation and capability of older farmers, farmers with lower levels of formal education, and the ones in more remote or financially disadvantaged regions (Rađenović, Krstić, & Marković, 2020; Vapa Tankosić, Mirjanić, Prodanović, Lekić, & Carić, 2024).

Younger and educated participants in various studies consistently show higher level of willingness to adopting tools like Big Data analytics, AI, and drone-based monitoring (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021) which is supported with the results of this study. Geographic differences, particularly between Vojvodina and southern Serbia, emphasize the need to address the issue through strengthening the infrastructure, introducing training opportunities, and establishing stronger institutional support (Jurjević, Zekić, Đokić, & Matkovski, 2019; Dimitrijević, Ristić, & Despotović, 2021; Grujić Vučkovski, & Subić, 2024). The absence of significant gender differences may indicate that women and men in Serbian agriculture share similar attitudes toward digitalization.

Conclusion

Serbia's agricultural sector stands at a decisive moment, especially in terms of empowering small farmers to understand and implement innovative solutions. Many of the small farmers, especially younger and more educated ones, already recognize the importance of implementing various digital tools in improving agricultural productivity. This calls for systemic effort to share basic knowledge and awareness between older farmers and to provide education and training for younger ones.

By developing committed strategies and policies, investing in digital infrastructure, and raising awareness among producers, the Serbian state can help ensure that agricultural transformation is both inclusive and resilient. Special attention should be given to practical training programs and the promotion of user-friendly digital tools, such as IoT systems, Big Data applications, and drones, which can be easily adopted and shared within farming communities. With the creation and implementation of these programs, especially if aligned with EU agricultural policies, even small farmers can be effectively integrated into modern agricultural systems, leading to significant improvements in productivity and sustainability.

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Conflict of interest

The authors declare no conflict of interest.

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