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E-government in agriculture: assessment of Serbian farmers' ability to use the digital platform eAgrar

E-uprava u poljoprivredi Srbije: procena sposobnost farmera u Srbiji da koriste digitalnu platformu eAgrar

Vesna PARAUŠIĆ (✉), Nataša KLJAJIĆ, Bojana BEKIĆ ŠARIĆ

Institute of Agricultural Economics, Volgina 15, 11000 Belgrade, Serbia

✉ Corresponding author: vparausic@gmail.com

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ABSTRACT

Digitalization of public administration services (e-government) is increasingly becoming prevalent in the agriculture sector in many countries, bringing numerous benefits to farmers and government authorities. However, the sustainability of these digital solutions is questionable, primarily due to the digital divide in rural areas. Using the example of Serbia and the implementation of the electronic information system (application) eAgrar, the authors examine the factors determining farmers' ability to use this application independently vs. requiring assistance. An online survey was conducted from April to December 2023 using a semi-structured questionnaire, which involved 510 farmers. Binary logistic regression was used for statistical inference. Results show that the following predictors have a statistically significant impact on respondents' ability to use eAgrar independently: the economic development of the region where the farm is situated, farmers' age and education, farm size, type of farming on the farm, and the application's adaptability to the local context, i.e., target users, both regarding the complexity of the software solution, and the availability of different types of IT support for farmers. The last predictor had the greatest impact on the studied dependent variable (Exp (B)=9.64; 95% CI 5.42, 17.14; *P*=0.000). The results indicate to government authorities that the sustainability of e-services in the agriculture sector requires an institutionally organized and extensive network of intermediaries for the digital training of farmers, as well as the software design of e-services that aligns with farmers' socio-economic characteristics and digital literacy.

Keywords: digitalisation of public services, farmers' digital literacy, farmers' attitudes, binary logistic regression, survey

SAŽETAK

Digitalizacija usluga državne uprave (e-uprava) sve je prisutnija u sektoru poljoprivrede u mnogim zemljama, donoseći brojne koristi za poljoprivrednike i organe vlasti. Ipak, održivost ovih digitalnih rešenja je upitna, prevashodno imajući u vidu digitalni jaz prisutan u ruralnim područjima. Na primeru Srbije i implementacije elektronskog informacionog sistema (aplikacije) eAgrar, autori ispituju faktore koji opredeljuju sposobnosti poljoprivrednika da ovu aplikaciju samostalno koriste vs. da im je potrebna pomoć. U online anketnom istraživanju anketirano je 510 poljoprivrednika, u periodu od aprila do decembra 2023. godine, korišćenjem polustrukturiranog upitnika. Za statističko zaključivanje korišćena je binarna logistička regresija. Rezultati su pokazali da na sposobnost ispitanika da samostalno koriste eAgrar, statistički značajan uticaj imaju sledeći prediktori: ekonomska razvijenost regiona u kome je sedište farme, godine i obrazovanje ispitanika, veličina farme, tip poljoprivredne proizvodnje na farmi i prilagođenost aplikacije lokalnom kontekstu, odnosno ciljnim korisnicima, kako sa aspekta složenosti softverskog rešenja, tako i sa aspekta osiguranja različitih vidova informatičke podrške poljoprivrednicima. Poslednji prediktor je imao najveći uticaj na ispitivanu zavisnu varijablu (Exp (B)=9.64; 95% CI 5.42, 17.14; *P*=0.000). Rezultati ukazuju državnim organima da održivost e-usluga u sektoru poljoprivrede zahteva institucionalno organizovanu i široku mrežu posrednika za digitalnu obuku poljoprivrednika, kao i softversko dizajniranje e-usluga koje je u skladu sa socio-ekonomskim karakteristikama poljoprivrednika i njihovom digitalnom pismenošću.

Ključne reči: digitalizacija javnih usluga, digitalna pismenost poljoprivrednika, stavovi poljoprivrednika, binarna logistička regresija, anketa

INTRODUCTION

Agriculture 4.0 technologies are increasingly directing the sector of agriculture towards digitalization, greater competitiveness and productivity, as well as greener and more sustainable practices (Bolfe et al., 2020; Ciruela-Lorenzo et al., 2020; Erdoğan, 2022; FAO, 2022; Kernecker et al., 2020; Pogorelskaia and Várallyai, 2020). For rural areas, these technologies, along with the digital literacy (DLY) of the population, represent an opportunity for revitalization and a path towards the creation of the so-called smart villages (Anastasiou et al., 2021; Ciruela-Lorenzo et al., 2020; Komorowski and Stanny, 2020; Malik et al., 2022; Rahoveanu et al., 2022; Sept, 2020; Stojanova et al., 2021).

Nowadays, within Agriculture 4.0 technologies, farmers have access to numerous information and communication solutions that use the internet and connectivity and belong to the group of low-complexity and less sophisticated technologies. These are primarily various mobile applications (apps), digital tools and platforms, such as e-marketing, e-commerce, social media marketing, information systems for mobile phones and computers, and alike (Alavion and Taghdisi, 2021; Bolfe et al., 2020; Elghannam et al., 2020; Emeana et al., 2020; FAO, 2022; Goedde et al. 2021; Khalil Moghaddam and Khatoon-Abadi, 2013; Khanal and Mishra, 2016; Morepje et al., 2024; Zhong et al., 2024). These solutions also encompass the digitalization of public services, specifically the services provided by government authorities, hereinafter referred to as "e-government".

According to the OECD's concise definition, *"e-government refers to the use by the governments of information and communication technologies (ICTs), and particularly the Internet, as a tool to achieve better government"* (OECD, 2014, p. 6). Such a government contributes to the more efficient supply and better quality of government services, and it is intensively being developed in all countries worldwide, directing economies and societies towards sustainable development (Ahmad, 2021; Dhaoui, 2022; Malodia et al., 2021; Regional Cooperation Council, 2022; UN, 2022; Zioło et al., 2022).

E-government is increasingly prevalent in the sector of agriculture and rural development. Sheikh and Berenyi (2023, p. 79) define it as *"utilization of modern information and communication technology to advance agriculture services that allow farmers to access related information"*. Digital government services change the existing patterns of communication and cooperation between farmers and government departments towards more efficient administrative procedures and facilitated exchange of data and information. Consequently, this leads to improved systems for management and decision-making in the sector of agriculture and rural development (Bournaris, 2020; Emeana et al., 2020; Goedde et al., 2021; Hoque and Al Kabir, 2024; Mushi et al., 2024; Naik, 2021; Panganiban, 2019; Reissig et al, 2022; Sheikh and Berenyi, 2023; Vázquez-López and Marey-Perez, 2021).

Therefore, e-government is particularly useful for alleviating numerous structural problems in the agriculture and rural development sector in low- and middle-income countries (Emeana et al., 2020; Goedde et al., 2021; Hoque and Al Kabir, 2024; Mushi et al., 2024; Naik et al., 2021; Panganiban, 2019; Radičić, 2022; Sheikh and Berenyi, 2023). On the other hand, it is in these countries that numerous factors limit the sustainable implementation of the government's digital apps and platforms. These factors primarily involve: (a) rural poverty and dominance of small-scale farmers with subsistence and semi-subsistence farming; (b) depopulation of rural areas (mainly due to migrations); (c) low DLY of farmers, as well as the unfavourable structure of the rural population regarding age and education; (d) insufficiently developed ICTs in rural areas, particularly in remote and sparsely populated regions (Anastasiou et al., 2021; Ciruela-Lorenzo et al., 2020; FAO, 2022; FAO, 2020; Goedde et al., 2021; Morepje et al., 2024; Mushi et al., 2024; Naik et al., 2021; Panganiban, 2019; Radičić, 2022; Sheikh and Berenyi, 2023; Stojanova et al., 2021). Another limitation is the fact that the government's apps are frequently not adjusted to the local context or the target users, which is accompanied by the lack of DLY among public sector employees (Emeana et al., 2020; Goedde et al., 2021; Malodia et al., 2021; Panganiban, 2019; Sheikh and Berenyi, 2023).

It is evident that these obstacles must be addressed, and the accumulated issues must be resolved to enable stakeholders in the agriculture and rural development sector in low- and middle-income countries to reap the benefits of the digital age. In doing so, it is important to remember that each country has its own policies and mechanisms for developing and implementing e-government services, which are largely defined by its political and economic situation, as well as institutional and infrastructural development, ICT progress and the achieved level of DLY of the population (Ahmad, 2021; Malodia et al., 2021; Panganiban, 2019).

Given the above, the question arises of how farmers in the Western Balkan countries (WBCs), which are all classified as middle-income countries (according to the World Bank country classification) and are part of the broader South Eastern Europe area, can successfully "deal with" the progress of e-government in their countries. The authors explore these questions using the example of the Republic of Serbia, the largest WBC by area and by population.

In Serbia, as well as in the other WBCs, agriculture represents a significant economic activity, but it is at the same time poorly organized, low in productivity, with fragmented land and the dominance of small-scale family farms with subsistence or semi-subsistence farming (Djordjević Milošević et al., 2021; EC, 2019; Erjavec et al., 2021; FAO 2020; Horvat et al, 2020; Nikolić et al., 2017; Paraušić et al., 2021). Although political aims are directed towards the EU accession, agricultural policy is not sufficiently adjusted to the EU's CAP, and the support for agriculture and rural development is still low and unstable (EC, 2019; Erjavec et al., 2021).

Simultaneously, Serbia shows exceptional progress in the digital transformation of public administration. It is ranked among the countries with a very high E-Government Development Index value (UN, 2022), and it is the regional leader in all dimensions of the Digital Economy and Society Index (including the fourth dimension of e-government) (Regional Cooperation Council, 2022). The IT infrastructure of e-government is continuously developed, while the availability of e-government services increases and data are made accessible (Ministry of Public Administration and local self-government of the Republic of Serbia, 2022). As part of these activities, the electronic platform (software solution or informational system) eAgrar was implemented in the agriculture sector in 2023. The introduction of this platform is supported by the appropriate legal framework (Official Gazette, 2021) and is part of the process of aligning Serbia with the EU's CAP (EC, 2023).

eAgrar is under the jurisdiction of the Ministry of Agriculture, Forestry and Water Management (MAFWM) and is mandatory for all farmers and other participants in the rural development who want to be part of the system of national incentives and subsidies (Official Gazette, 2021). It is a unique, centralized, electronic database of agricultural holdings, where all records and changes related to holdings, including requests for subsidies, are electronically managed (Official Gazette, 2021; Radičić, 2022). According to the information obtained from MAFWM, as of December 2024, 495,123 agricultural holdings in Serbia are registered within this app, which accounts for 97% of the total number of registered holdings in the 2023 Agricultural Census (Statistical Office of the Republic of Serbia, database).

The subject of the authors' research is the analysis of factors which might affect farmers' ability to use the eAgrar app independently in Serbia (as opposed to requiring assistance). The paper aims to obtain insights into the key predictors of farmers' greater ability to operate this government app, which indirectly provides information on the factors affecting farmers' DLY. The results are pragmatic and clearly show policymakers which factors should be targeted by public policy measures in order to ensure greater adoption of government apps and the sustainability of government software solutions in practice.

LITERATURE REVIEW

Although the presence of government digital platforms and apps in the agriculture sector is still modest and lags behind other sectors of the economy (Alassaf and Szalay, 2020), they are increasingly being developed in this sector as well.

The following text provides examples of experiences related to their implementation in low- and middle-income countries.

- Panganiban (2019) underlines that although the Philippines has numerous structural problems related to the agriculture sector, e-government is successfully implemented, providing numerous benefits to both farmers and the Philippines' Department of Agriculture. Due to the low DLY of farmers, significant attention has been given to their training in using digital government services. Numerous intermediaries have been engaged (advisory services, local government units, centres for providing information and IT training), while social media platforms have been very useful for spreading information.
- A similar situation was observed in Bangladesh. Users of the digitalized government service in agriculture expressed high satisfaction with access to services and information, as well as with improved administrative procedures, which led to increased productivity in this sector (Hoque and Al Kabir, 2024; Sheikh and Berenyi, 2023). However, according to Sheikh and Berenyi (2023), the primary obstacle to the adoption of e-government is small-scale farmers who have low DLY, overall limited business capacity and restricted access to resources in production. According to these authors, there are also limitations in terms of unfavourable network bandwidth in rural regions, as well as the insufficient support for farmers through various digital service centres and extension services.
- Naik (2021) states that ICTs are crucial for improving rural areas and increasing the standard of living for rural populations in India. Recognizing the importance of farmers' DLY, the government in Kerala (India) started the Akshaia project (project of e-literacy) as part of its e-governance initiatives. Initially developed in the rural areas of the Malappuram district, the project was later expanded throughout the country (Naik, 2021). Establishing information kiosks in the rural areas of India through the eGram project was specifically aimed at promoting and encouraging the inclusion of vulnerable groups of the rural population into the e-government system (Malodia et al., 2021).
- Numerous government agricultural information services, such as m-Agri services and e-wallets, are available in African countries intending to transform the agriculture of these countries towards greater sustainability and competitiveness (Abdulai et al., 2023; Emeana et al., 2020; Goedde et al., 2021; Mushi et al., 2024). Nevertheless, farmers are not always satisfied with these digital apps, and their mere existence does not guarantee that they will be accepted by small-scale farmers. Most government apps are used by a very small number of users, and consequently, they fail to make a positive contribution to farmers' incomes and quality of life (Emeana et al., 2020; Goedde et al., 2021). This is most frequently caused by the lack of adaptation of the app content to the local context. i.e. to the target users (small-scale farmers), as well as by the generally inadequate ICT infrastructure in rural areas (Emeana et al., 2020; Goedde et al., 2021; Mushi et al., 2024). As underlined by Emeana et al. (2020, p. 1), *"services are highly likely to fail to achieve their intended purpose or be abandoned when implementers ignore the literacy, skills, culture, and demands of the target users"*. Examining the factors that influence the participation of small-scale farmers in the government's digital agricultural initiatives in Northern Ghana, Abdulai et al. (2023) conclude that governments must consider the local context when designing these initiatives, ensuring their adaptability to the socio-economic conditions and other characteristics of farmers. This group of authors highlight that the following small-scale farmers are more likely to participate in digital initiatives: male farmers, members of farmers' associations, those with access to advisory extension services, and those who have mobile phones and are able to make phone calls.

Experiences differ when it comes to high-income economies. Evaluation of e-government services in agriculture in Greece (examining users of the services of the government web portal agroGOV) showed that the users were satisfied with e-government services, and that they placed great importance on the interaction and accessibility of the government portal for end users (Bournaris, 2020). Farmers in Switzerland are obliged to use e-government services, but they believe that digital administrative procedures bring no benefits to the farm (in terms of increasing productivity or income), and instead, they perceive them as an administrative burden (Reissig et al., 2022). Similarly, dairy farmers in Spain are not very satisfied with the implementation of e-government services and digitalized administrative procedures, which do not meet their expectations regarding time and cost savings (Vázquez-López and Marey-Perez, 2021). Farmers evaluate digitalized government procedures as excessively complex and insufficiently clear, and they state that the quality of the internet connection on their farms is poor. In addition, low farmers' DLY and high uncertainty related to working with government procedures resulted in *"calls to telephone customer service, trips to regional agrarian offices or outsourcing authorised entities"* (Vázquez-López and Marey-Perez, 2021, p. 14).

MATERIALS AND METHODS

For the needs of the research and data collection, the authors used survey research as the methodology, which is best suited to the established research subject and aim (Sapsford, 2007). The research was conducted online using the Google Forms tool, while the population consisted of family agricultural holdings located in Serbia.

Purposeful random sampling was used, which means that the sample involves farmers (representatives of family farms) who use smartphones, are members of farmers' associations, use the Viber community of their association and are registered on the eAgrar portal. In order to collect data, the researchers first contacted the administrators of seven farmers' associations, asked them to post the survey link in the association's Viber community and request farmers to fill it out. Anonymity was guaranteed. The survey was carried out from April to December 2023, and a total of 510 responses were collected. The semi-structured questionnaire contained open-ended and closed-ended questions. For the purposes of this paper, part of the data relevant to the subject was used.

The dependent (criterion) variable was formulated using the question: "Do you use the eAgrar app independently or do you require assistance? ". Two responses were offered: (1) Yes, I can use the app independently; (2) No, I cannot use the app independently (I require assistance).

The predictor (independent) variables are presented in Table 1. They include socio-economic and business characteristics of farmers (age, education, farm size, type of farming); spatial context (the farm's location in the economically developed vs. undeveloped region); motivation (expected benefits from using the app) and adaptation of the app to the local context. The selection of these factors was based on a comprehensive review of the literature in this and related research fields both in Serbia (Dašić, et al., 2023; Ilić-Kosanović et al., 2019; Jurjević et al., 2019; Kovljenić et al., 2023; Radičić, 2022), and in other countries and regions worldwide (Abdulai et al., 2023; Alavion and Taghdisi, 2021; Anastasiou et al., 2021; Emeana et al., 2020; Goedde et al., 2021; Kernecker et al., 2020; Khalil Moghaddam and Khatoon-Abadi, 2013; Reissig et al., 2022; Sheikh and Berenyi, 2023; Zhong et al., 2024).

The authors used descriptive statistics and binary logistic regression to statistically test the impact of different independent variables on farmers' independence in using the eAgrar app. In our binary logistic regression model, the dependent variable is dichotomous and coded as 0: No, I cannot use the app independently (I require assistance) and 1: Yes, I can use the app independently. All predictor variables are categorical (binary or with several categories) and were simultaneously entered into the model. The logistic regression coefficients were estimated using the maximum likelihood model, and all assumptions for the application of the selected statistical technique were fulfilled: a random and large sample; absence

Table 1. Predictor variables included in the binary logistic regression model/[1]

Predictor variables	Variable categories	Code
Region (NUTS 1)/[2]	Undeveloped region (Serbia South)	0
	Developed region (Serbia North)	1
Age of the farmer	Young farmers (40 years and younger)	0
	Middle-aged farmers (41-59)	1
	Elderly farmers (60 years and above)	2
Education of farmers	Lower level of education (primary and/or secondary school)	0
	Higher level of education (college diploma, master's degree, doctorate)	1
Farm size (in ha)	Small-scale farm (up to 10 ha)	0
	Medium-scale farm (10-49.9 ha)	1
	Large-scale farm (50 ha and over)	2
Type of farming	Specialist farms: field crops	1
	Specialist farms: animal production	2
	Specialist farms: permanent crops (vineyards or/and fruit)	3
	Mixed cropping farms	4
	Mixed farms: crops-livestock	0
Expected benefit of the app (motivation for using the app)	No, I will not have any benefits	0
	Yes, I expect benefits	1
Adaptation of the app to the local context/[3]	Insufficiently adapted	0
	Well-adapted	1

/[1] For all predictor variables, the first category (0) is the reference category, except for the variable Type of farming, where the reference category is the last one (Mixed farms: crops-livestock).

/[2] The respondents were grouped in two regions (developed vs. undeveloped) according to the farm's location and classification of regions according to their economic development (Official Gazette, 2014; Stamenković et al., 2021).

/[3] This refers to adapting the software to farmers' DLY and socio-economic characteristics, as well as providing various types of support to help farmers use this app effectively.

Source: The authors' own research

of expressed multicollinearity between the predictor variables; and linearity. For significant predictors ($P<0.05$), the Exp(B) (odds ratios for the predictors) column (Table 3) was considered. The complete statistical analysis was performed using the SPSS 21.0 software (IBM, Chicago, USA).

RESULTS AND DISCUSSION

Descriptively presented research results

Considering the data for the defined dependent variable, the results of the survey show that a high percentage of respondents (74.7%) are capable of using

the eAgrar app independently. This group reported using the MAFWM website, where various forms of support are available on the eAgrar portal (Ministry of Agriculture, Forestry and Water management of the RS, 2024), such as video clips, guidelines, information, contact information of agricultural extension officers, the eAgrar call centre, the contact form for sending questions via email, etc. If they still encounter any problems or uncertainties while using the app, farmers seek advice from agricultural extension officers who have been delegated by MAFWM to provide support to farmers in the early stages of the eAgrar implementation.

Compared to this group, 25.3% of respondents stated that they could not use the app independently and that they required assistance. This group of farmers primarily seeks assistance from agricultural extension officers and employees in local government units. In addition, they also ask for support from younger members of their households and/or their relatives, friends or acquaintances who have successfully used the app or are digitally literate.

Table 2 provides a description of the sample according to the defined predictor variables.

Table 2. Sample characteristics according to the predictor variables

		Number	%	∑ (%)
Region	Developed region (Serbia North)	288	56.5	100
	Undeveloped region (Serbia South)	222	43.5	
Age	Young farmers (40 years and younger)	245	48.0	
	Middle-aged farmers (41-59)	225	44.1	100
	Elderly farmers (60+)	40	7.8	
Education	Lower level of education (primary and/or secondary school)	308	60.4	100
	Higher level of education (college diploma, master's degree, doctorate)	202	39.6	
Farm size	Small-scale farms (farmers cultivating up to 10 ha)	232	45.5	
	Medium-scale farms (farmers cultivating from 10 to 49.9 ha)	205	40.2	100
	Large-scale farms (farmers cultivating 50 ha and more)	73	14.3	
Type of farming	Specialist farms: field crops	177	34.7	
	Specialist farms: animal production	54	10.6	
	Specialist farms: permanent crops (vineyards or/and fruit)	74	14.5	100
	Mixed cropping farms	32	6.3	
	Mixed farms: crops-livestock	173	33.9	
Expected benefit of the app	No, I will not have any benefits	149	29.2	100
	Yes, I expect benefits	361	70.8	
Adaptation of the app to the local context	Insufficiently adapted	176	34.5	100
	Well-adapted	334	65.5	

Source: The authors' own research

Results of binary logistic regression with discussion

The binary logistic regression model used in this paper is suitable and statistically significant. In other words, the selected predictor variables significantly contribute to the explanation of the variations of the criterion (dependent) variable ($\chi^2(12) = 174.003$, P=0.000) (Table 3).

Table 3. Omnibus Tests of Model Coefficients

		Chi-square	df	Sig.
Step 1	Step	174.003	12	0.000
	Block	174.003	12	0.000
	Model	174.003	12	0.000

Source: SPSS Output

The validity of the model was also confirmed by the results of the Hosmer and Lemeshow Test ($\chi^2(8) = 5.902$, P=0.658) (Table 4).

Table 4. Hosmer and Lemeshow Test

Step	Chi-square	df	Sig.
1	5.902	8	0.658

Source: SPSS Output

The final model explains between 29% (Cox and Snell R2) and 43% (Nagelkerke R2) of the variance of the dependent variable and correctly classifies the total of 82.5% cases (Table 5, Table 6).

Table 5. Model summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	402.852[a]	0.289	0.427

[a] Estimation terminated at iteration number 5 because parameter estimates changed by less than 0.001

Source: SPSS Output

The results in Table 7 show that the following predictors have a unique and statistically significant impact on the prediction of the variations of the criterion variable *(I use the eAgrar app independently):* (1) the region where the farm is situated (farm location); (2) farmers' age; (3) farmers' education; (4) farm size; (5) type of farming and (6) adaptation of the app to the local context. Practically speaking, out of the seven selected predictor variables, only the variable *Expected benefit of using the eAgrar app* has no statistically significant influence on the criterion variable. This indicates that the authors made a sound choice when selecting the variables which were to be included in the final logistic regression model.

The analysis of the results from Table 7 indicates the following:

- Compared to farmers in the undeveloped region, farmers in the developed region of Serbia are 2.7 times more likely to use the app independently, when all other predictor variables are kept constant (Exp (B)=2.70; 95% CI 1.46, 4.99; P=0.001). This is in concordance with the authors stating that the economic development of a country is correlated with the higher DLY of its population (Antonijević et al., 2023), as well as that a strong economy represents one of the moderators of e-government (Malodia et al., 2021).
- Younger and more educated farmers are more likely to use the app independently. For example, middle-aged farmers are 0.32 less likely to use the app independently than young farmers, when all other predictor variables are held constant (Exp (B)=0.32; 95% CI 0.19, 0.55; P=0.000). Also, compared to young farmers, elderly farmers are 0.28 less likely to use the app independently (Exp (B)=0.28; 95% CI 0.12, 0.67; P=0.004). More educated farmers (with a university degree or higher education) are 2 times more likely to use the app independently than less educated farmers (with primary and/or secondary education), when all other predictor variables are held constant (Exp (B)=1.98; 95% CI 1.13, 3.46; P=0.017). In Serbia, there is only one study dealing with the electronic information system eAgrar. Here, the author emphasizes the possible non-acceptance of this app by farmers due to their unfavourable age and educational structure, as well as low DLY

Table 6. Classification Table[a, b]

Observed			Do you use the app independently?		Percentage Correct
			Assistance required	Independently	
Step 0	Do you use the app independently?	Assistance required	0	129	0.0
		Independently	0	381	100.0
				Overall Percentage	74.7
Step 1	Do you use the app independently?	Assistance required	73	56	56.6
		Independently	33	348	91.3
				Overall Percentage	82.5

[a] For Step 0. The constant is included in the model. The cut value is 0.500
[b] For Step 1: The cut value is 0.500

Source: SPSS Output

Table 7. Variables in the equation

Predictor variables	B	S.E.	Wald	Df	Sig.	Exp (B)	95% CI.for EXP (B)	
							Lower	Upper
Developed region	0.994	0.313	10.110	1	0.001	2.702	1.464	4.985
Age of the farmer			18.981	2	0.000			
Middle-aged farmers (41-59)	-1.133	0.276	16.920	1	0.000	0.322	0.188	0.553
Elderly farmers (60 and over)	-1.263	0.440	8.252	1	0.004	0.283	0.120	0.670
Higher level of education	0.681	0.286	5.690	1	0.017	1.976	1.129	3.459
Farm size, ha			7.747	2	0.021			
Medium-scale farm (10-49.9ha)	-0.579	0.311	3.459	1	0.063	0.560	0.304	1.032
Large-scale farm (50 ha and over)	-1.192	0.439	7.379	1	0.007	0.304	0.128	0.717
Type of farming			7.339	4	0.119			
Specialist farms: field crops	0.785	0.356	4.853	1	0.028	2.192	1.090	4.408
Specialist farms: animal production	0.172	0.458	0.141	1	0.708	1.187	0.484	2.913
Specialist farms: permanent crops	-0.417	0.413	1.017	1	0.313	0.659	0.293	1.482
Mixed cropping farms	0.315	0.617	0.261	1	0.610	1.371	0.409	4.597
Expected benefit of using the app	0.424	0.294	2.076	1	0.150	1.528	0.858	2.718
Adaptation of the app to the local context	2.266	0.294	59.539	1	0.000	9.638	5.420	17.136
Constant	-0.277	0.374	0.548	1	0.459	0.758		

Source: SPSS Output

(Radičić, 2022). Otherwise, numerous authors, both in Serbia (Dašić, et al., 2023; Ilić-Kosanović et al., 2019; Jurjević et al., 2019; Kovljenić et al., 2023), and globally (Anastasiou et al.; 2021; Khalil Moghaddam and Khatoon-Abadi, 2013; Mushi et al., 2024; Naik, 2021; Rahoveanu et al., 2022; Sheikh and Berenyi, 2023; Vázquez-López and Marey-Perez, 2021; Zhong et al., 2024) emphasize the unfavourable age and educational structure of farmers, as factors that influence the digital divide and weaker acceptance of the Internet in the agriculture and rural development sector;

- Large-scale farmers are 0.3 times less likely to use the app independently than small-scale farmers, when all other predictors are kept constant (Exp (B)=0.30; 95% CI 0.13, 0.72; *P*=0.007). This predictor (physical size of the farm or, indirectly, farmers' economic power) shows that the increase in the farms' size does not enhance farmers' ability to use the app independently; on the contrary, it decreases this ability. This can be explained by the assumption that large-scale farmers, due to their greater involvement in agricultural production, probably lack the time to work with the app, or they delegate these tasks to younger members of their households or other individuals. In general, while larger farm size and financially stronger farmers are an important prerequisite for greater application of innovations and digitalization of agriculture in Serbia (FAO, 2022; Jurjević et al., 2019; Kovljenić et al., 2023) the situation is different when it comes to the acceptance of e-government. Also, regarding this predictor, we can conclude that our results are not in line with the results of Abdulai et al. (2023), Goedde et al. (2021) or Sheikh and Berenyi (2023), who believe that the main obstacle to the greater acceptance of e-government in agriculture is precisely small-scale farmers.
- Compared to holders of mixed farms (crops-livestock), farmers specializing in field crops are 2.2 times more likely to use the app independently when all other predictors are held constant (Exp (B)=2.19; 95% CI 1.09, 4.41; *P*=0.028). Among other things, this can be explained by the assumption that the farmers from the latter group, due to the greater level of mechanization of their production processes, have more free time, as well as the time to explore different digital solutions available in daily business.
- Finally, farmers stating that the app is well adapted to the local context are 9.6 times more likely to use the app independently when all other predictors are held constant, compared to farmers who state that the app is insufficiently adapted (Exp (B)=9.64; 95% CI 5.42, 17.14; *P*=0.000). This is the strongest predictor in our model. Numerous other authors have also underlined the need for the government to adapt the apps in the agriculture sector to the target users (farmers, particularly small-scale ones) both in terms of the complexity of the software solution and in terms of ensuring different forms of support for farmers (Abdulai et al., 2023; Bournaris, 2020; Emeana, et al., 2020; Goedde et al., 2021; Malodia et al., 2021; Panganiban, 2019; Sheikh and Berenyi, 2023; Vázquez-López and Marey-Perez, 2021).

Recommendations

In this section, the authors provide key assumptions for the wider acceptance of e-government in the agriculture and rural development sector in Serbia, which can also be applied to other WBCs. They are under the jurisdiction of the government, i.e. the relevant ministries, and should be an integral part of national policies and measures. They ensure that the government's digital initiatives are practically adopted (particularly by small-scale farmers), sustainable, and that they enable target users to benefit from electronic communication with public administration. According to the authors, the most important assumptions are the following:

- Software and technical adaptation of digital initiatives to farmers, bearing in mind their level of digital literacy, socio-economic characteristics, requirements, customs and norms in the local environment. This need was recognized by numerous other authors (Abdulai et al., 2023; Bournaris, 2020; Emeana, et al., 2020; Goedde et al., 2021; Malodia et al., 2021; Panganiban,

2019; Sheikh and Berenyi, 2023; Vázquez-López and Marey-Perez, 2021). Sheikh and Berenyi (2023, p. 81) underline that *"this demands research and development efforts that concentrate on developing new technologies that are affordable, accessible, and easy to use for small scale farmers"*.

- Alleviating the digital divide in society by educating farmers and strengthening their digital literacy and awareness. Throughout the literature there is an evident need for programs to inform, educate and train farmers in the field of ICTs in order to prepare them for the new digital era and teach them to use all its advantages (Abdulai et al., 2023; Bejaković et al., 2020; Chohan and Hu, 2022; Dhaoui, 2022; Malodia et al., 2021; Mokhtar et al., 2022; Naik et al., 2021; Panganiban, 2019; Pogorelskaia and Várallyai, 2020; Rahoveanu et al., 2022; Sheikh and Berenyi, 2023; Stojanova et al., 2021).
- Ensuring different forms of IT support for the digital empowerment of farmers by establishing an extensive network of channels of intermediaries at the local level. By opening local centres or offices for the digital training of farmers, hiring agricultural extension officers in agricultural extension services, as well as employees in local government units, many countries have ensured (or might ensure) wider acceptance of government apps in the agriculture sector (Abdulai et al., 2023; Goedde et al., 2021; Hoque and Kabir, 2024; Malodia et al., 2021; Panganiban, 2019; Sheikh and Berenyi, 2023). For example, an extensive network of agricultural extension services and exceptional involvement of agricultural extension officers were the key catalysts of the successful implementation of the eAgrar digital platform in Serbia.
- The government's focus is on strengthening the ICT sector and digital infrastructure in rural areas, particularly in sparsely populated and inaccessible regions. This is extremely significant, as the digital divide present in many countries is mainly caused by the insufficient availability of digital devices and tools in rural households, as well as the lack of internet and wireless networks in these areas (Anastasiou et al., 2021; Goedde et al., 2021; Komorowski and Stanny, 2020; Malik et al., 2022; Malodia et al., 2021; Mushi et al., 2024; Stojanova et al., 2021).
- The country's economic development and political stability (Antonijević et al., 2023; Malodia et al., 2021).

CONCLUSION

In every country, the sustainability of e-government in the agriculture sector is greatly determined by farmers' digital skills, as well as their ability to accept and independently use software solutions. On the other hand, these skills and abilities are influenced by a large number of factors, both the ones related to farmers and the ones related to the creators of government e-services.

Given the above, the authors studied the factors that influence the independence of farmers in Serbia in using the electronic information system eAgrar, which had been implemented as mandatory in 2023. Data were collected through an online survey, including 510 farmers, conducted from April to December 2023. Purposeful random sampling was used, and the sample consists of the representatives of family farms who use smartphones, are members of farmers' associations, use the Viber community of their association and are registered in the eAgrar app.

Using binary logistic regression, the authors concluded that the following respondent groups were more likely to use this app independently: (a) younger and more educated farmers (compared to older and less educated ones); (b) farmers in the economically more developed region (compared to those in the undeveloped region); (c) small-scale farmers compared to large-scale farmers; (d) farmers specializing in field crops compared to holders of mixed farms (crops-livestock); (e) those who perceive the app as well adapted to the local context (to the target users), both regarding the complexity of the software solution and ensuring different forms of IT support to farmers. The last predictor had the greatest impact on the studied dependent variable. Namely, the respondents who perceived the application as well adapted to the local context were 9.6 times more likely to

use it independently when all other predictors were held constant (Exp (B)=9.64; 95% CI 5.42, 17.14; *P*=0.000).

The results of the study enrich the limited scientific knowledge in this field in European countries and provide guidance to policymakers on which factors should be targeted by public policy measures to ensure greater sustainability and increase farmers' acceptance of government e-services. Also, recommendations clearly indicate to government authorities that the sustainability of e-services in the agriculture sector requires institutionally organized, extensive networks of intermediaries for the digital training of farmers, as well as the software design of e-services which aligns with the socio-economic characteristics of farmers and their digital literacy.

Given that the study examined farmers' attitudes, subjectivity represents an unavoidable limitation of the paper, although the authors attempted to mitigate it using a large sample. Also, the socio-economic characteristics of the respondents in the sample are more favourable compared to the population, which is the result of defined criteria for selecting research participants. Nevertheless, our results may apply to the entire population of farmers, with the emphasis that the influence of the predictors on the examined dependent variable would probably be greater if the sample did not include only participants of the Viber communities of the farmers' associations.

The obtained results can be further complemented by studying farmers' observations on acceptance of other, highly sophisticated Agriculture 4.0 solutions and analysis of predictors for acceptance of these solutions. This could also be valuable for policymakers when creating agricultural policy measures aimed at enhancing digitalization of agriculture.

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