ECONOMIC ASPECTS OF DIGITALIZATION IN SERBIAN AGRICULTURE: FARMERS' ATTITUDES

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ABSTRACT

One of the ways to achieve economic, environmental, and social sustainability in agriculture is to introduce digitalization in the production process or its digital transformation. The primary research objective in this paper is to obtain empirical knowledge about the various economic aspects of investing in digitalization in Serbian agriculture. The research relies on interviews conducted in the period April-October 2023 using a semi-structured questionnaire, covering a sample of 53 agricultural holdings on the entire territory of Serbia. The results show that the interviewed farm managers do not show a high degree of satisfaction with the achieved level of digitalization on the farms they manage. Nevertheless, based on the analysis of economic parameters of investment in digital solutions (return on investment period, perceived benefits, costs, investment limitations, financial support), the largest percentage of respondents (56.6%) intends to intensify investments in digitalization on their farm in the next period.

Introduction

Agriculture 4.0 represents the fourth agricultural revolution, involving the use of digital technology and becoming an important factor in economic growth and the creation of more resilient, sustainable and environmentally responsible agriculture (Kljajić et al., 2016; Pogorelskaia & Várallyai, 2020; Javaid et al., 2022). What is more, information and communication technologies (acronym ICTs), when applied in agriculture, have an impact on the country as a whole (Sinitsa et al., 2021). Digital technologies rely on the

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use of electronics, robotics, drones, computing devices, genetic engineering and imply intensive use of ICTs and other already existing technologies, such as telephones, television, radio and satellites (Javaid et al., 2022). In general, smart farming is a new trend of services to agricultural producers using digital platforms and integrated ICTs, which reduces production costs and losses, increases productivity and profitability, and boosts competitiveness and farmers' living standard (Jurjević et al., 2019; Latif Virk et al., 2020; Pogorelskaia & Várallyai, 2020; Javaid et al., 2022; Tankosić et al., 2024).

Serbia has very favourable conditions for the development of various types of agricultural products, and the need for digitalization, innovation, modern agro technical solutions and ICTs in agriculture is extremely high (Jurjević et al., 2019; ITU & FAO, 2020). On the other hand, a significant limitation on the road to modernization and digitalization of agriculture lies in fragmented domestic agriculture. Namely, farmers are mostly owners of family farms, most often small-scale farms, with numerous unfavourable structural, production and financial characteristics (Paraušić, Roljević Nikolić & Subić, 2019; FAO, 2020; Paraušić, Subić & Roljević Nikolić, 2021; Jurjević et al., 2022; Kovljenić et al., 2023).

Due to above, innovations and good digitalization practices in Serbian agriculture are not so common (Kljajić, Paraušić & Rodić, 2016; Jurjević et al., 2019; Subić, Kljajić & Jeločnik, 2017; FAO, 2020; ITU & FAO, 2020; Kovljenić et al., 2023). The authors' empirical research shows that agricultural producers have a hard time deciding on the implementation of digital solutions, both because of the high costs of purchasing various digital systems, devices, and equipment, as well as because they do not have enough information about the advantages of their application. A small number of farmers is aware and know what digitalization is and how much it can boost the process of agricultural production. What is more, a large number of farmers are sceptical about innovations if they deviate from production tradition and embedded cultural and social norms.

The research subject in this paper are the views of agricultural farm managers in Serbia on the economic dimension of sustainability of investments in digitalization of agricultural production and business processes. Their perceptions regarding the benefits and costs of digitalization, the limitations they face in this process, as well as their views on the profitability of investments (return on investment period) and financial support (incentives) for these investments are examined. The authors indirectly assess the extent of economic sustainability of investments in digitalization in agriculture through a question about the intensity in which the respondents intend to invest in digitalization on their farms in the coming period.

The research objectives are to obtain empirical knowledge and better understand the economic aspects of digital agriculture (acronym DA) in Serbia, as well as test the possibility and feasibility of undertaking larger and more extensive research in the coming period (Payne & Payne, 2004; Babbie, 2008). The knowledge will be useful both to the scientific community and to farmers and agrarian policy makers. Also, the results will be useful as policy makers to plan future support, both to suppliers of agricultural techniques and ICTs and to their users, i.e. agricultural producers.

Materials and methods

Research on the economic aspects of DA sustainability covered the territory of the Republic of Serbia in the period April-October 2023. It examined the views of farm managers, i.e. *"persons responsible for the daily making and implementation of farm-related production and financial decisions"* (Statistical Office of the Republic of Serbia, 2019). The authors got the managers' contact data (phone numbers, email addresses) from the "Ruma Farmers' Association", which gathers farmers from all over Serbia.

A simple random sample included 53 respondents, and the conditions for participation in the research were as follows: (a) the respondent is a manager of an agricultural holding registered either in the Register of Agricultural Holdings or in the Business Registers Agency; (b) one or more business and production digitalization solutions are applied on the farm managed by the respondent. Respondents (agricultural managers) were from 19 areas on the territory of the Republic of Serbia, which makes the sample representative from a territorial point of view.

Qualitative research was conducted using the interview method and using a semi-structured interview (Kallio et al., 2016). In order to examine the respondents' views on sustainability of investment in business digitalization, a number of questions were designed, and for the purposes of this paper and the analysis of the economic sustainability of investment in business digitalization, only one set of questions (relevant to the subject research) was analysed. The questions were formulated based on an extensive literature review (presented in the introduction of the paper), as well as on the authors' perceptions and experiences related to the research area. Respondents gave some answers in free form, while in some questions they could circle an answer or scale an item on a Likert scale.

The questions in the semi-structured questionnaire, relevant to the subject of the paper, can be grouped into three groups: (1) the first part of the questionnaire included general questions related to the farm (name and seat; business form; number of persons on the farm involved in agricultural production; dominant production line on the farm; number of hectares cultivated on the farm); (b) the second part of the questionnaire asked the respondents to describe the current practice of business digitalization (which DA solutions they use, in which processes, in what percentage, etc.); (c) the third part of the questionnaire included the following questions to assess the economic sustainability of investing in DA solutions: what benefits does the application of DA solutions brings; what costs do you incur when introducing DA solutions; what are the biggest limitations for greater application of DA solutions; in what period can you expect a return on investment in DA solutions; evaluation of the financial support of the line ministry and local authorities for greater application of digitalization in agriculture; assessment of the degree of personal activity (agility) in finding different support programs (EU support, national support programs and the like) for financing investments in DA solutions (self-evaluation); plans for the intensity of future investments in digitalization in relation to the current situation (Scheme 1).

Some respondents were interviewed by telephone, with a conversation lasting 45 to 60 minutes. From other respondents, the answers were collected directly, through direct conversation with the producers. In data collection and analysis, the authors had an objective and unbiased attitude (Payne & Payne, 2004). All answers were summarized, analysed and presented in the form of research results, in tables and graphs. The qualitative content analysis method was used to analyse the responses received in free form (Kuckartz, 2019).

Results and discussion

The research results are presented through the description of the sample structure, and then through the respondents' views on the current application of DA on the farm, as well as the economic sustainability of investing in various digitalization solutions on the farm.

Sample description

The sample includes 53 respondents (agricultural managers on agricultural farms) from 19 areas on the territory of Republic of Serbia (South Banat, North Banat, South Bačka, Central Bačka, North Bačka, West Bačka, Srem, Belgrade, Danube, Pomoravlje, Šumadija, Kolubara, Mačva, Zlatibor, Nišava, Jablanica, Rasina, Raška and Pčinja districts).

All agricultural holdings are registered in the appropriate registers (Register of Agricultural Holdings, Business Registers Agency). According to the legal form, 44 agricultural holdings (83%) are family agricultural holdings, and 7 (13.2%) are companies. The sample includes one entrepreneur, as well as one agricultural cooperative.

According to the surface of land they cultivate (ownership + lease), the largest number of farms own 5-20 ha of land (20 of them or 37.7%). 18 farms (34%) are small holdings (up to 5 ha) and 9 farms (17%) are holdings from 20 ha to 100 ha. A total of 6 farms (11.3%) cultivate 100 ha and more.

On the largest number of farms (34 of them or 64.2%), up to two people are engaged in the production process, and from 3-5 people on 16 farms or 30.2%.

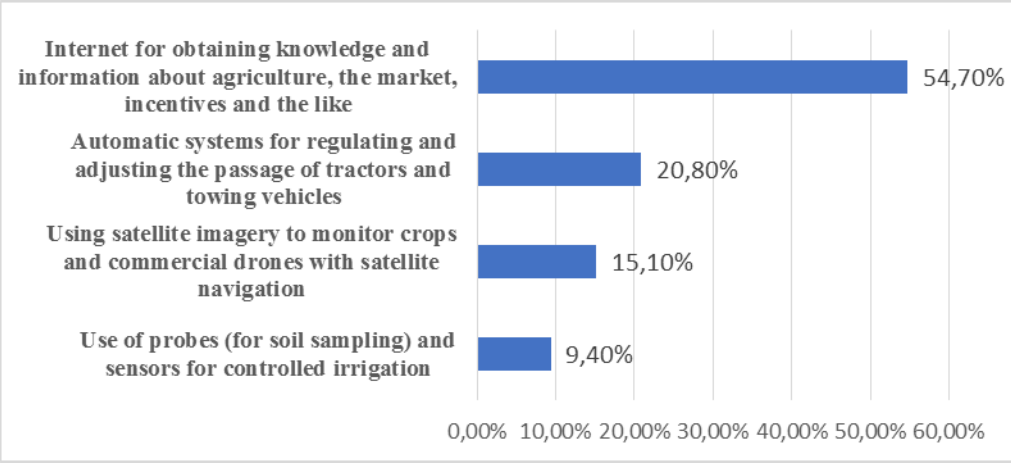
The largest number of farms (34%) has mixed agricultural production. Crop farming is the dominant type of production in 32.1% of farms, fruit growing and/or viticulture is the dominant type of production in 18.9% of farms, and 15.1% of farms in the sample are predominantly engaged in livestock production.

Application of agricultural digitalization solutions: views of interviewed agricultural managers

The interviewed agricultural managers on the farm apply different digitalization solutions in the process of agricultural production and business. Figure 1 shows digitalization solutions used in absolute numbers and as a percentage. Figure 1 shows that, of the total number of respondents, the largest share (55%) use the Internet in their production to collect information and news about agriculture, the market, incentives

and the like. A significantly smaller number of interviewed managers declare that they use some of the more advanced digitalization solutions in their business and production processes (automatic systems for regulating and adjusting the passage of tractors and towing vehicles; satellite images and commercial drones to monitor crops; probes and sensors for soil sampling and irrigation control).

Figure 1. Digital agriculture solutions that agricultural managers use on their farms, answer structure

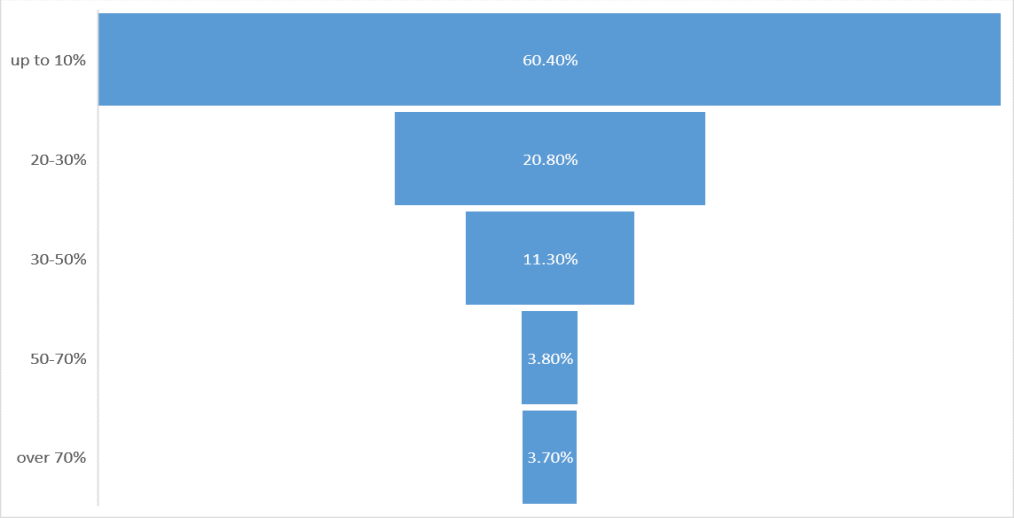


Source: Authors' presentation based on respondents' answers

Khanal & Mishra (2016) state that the Internet is one of the best digitalization options for small agricultural enterprises to collect information related to production and new markets, product sales, e-commerce, communication and social networking, etc. Our producers' practice correlates with this statement. Using the example of small-scale farmers in the USA, Khanal & Mishra (2016, p. 553) indicate that the financial performance (total household income, off-farm income, gross cash income) of small farm business households was higher in the group of farmers who used the Internet, compared to the control group (small-scale farmers who did not use the Internet).

60.4% of respondents have replaced work and production processes by digital agriculture solutions up to 10%. 20.8% of respondents have replaced production processes by digital agriculture solutions from 20-30%, 11.3% of respondents replaced them from 30-50%, while other respondents (7.6%) apply DA solutions in their work and production processes 50- 70% or over 70% (Figure 2).

Figure 2. Replacement of business and production processes in agriculture with digitalization solutions: percentage of responses



Source: Authors' presentation based on respondents' answers

The interviewed agricultural managers emphasize that they mainly apply digitalization solutions in the following business and production processes: (a) soil cultivation, sowing, fertilizing, irrigation and crop protection (dominantly in agriculture and vegetable growing); (b) heating and automatic regulation of ventilation in greenhouses; (c) monitoring of the production process (measurement and supervision); (d) marketing and sales of products; (e) information on the market and subsidies and incentives.

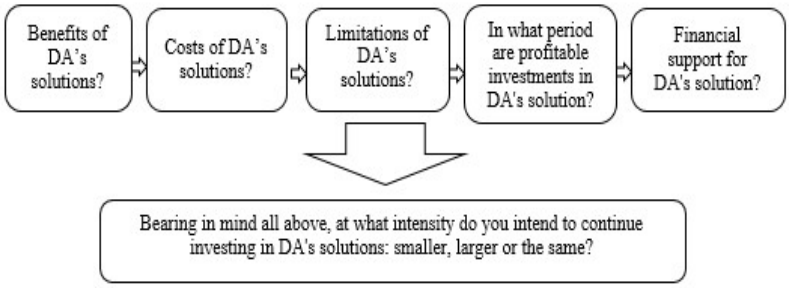
About a third of the respondents (more precisely 35.8%) develop digital solutions by themselves or in cooperation with one of the family members, 30.2% of respondents purchase solutions on the market, while 34% of them combine these two possibilities.

Finally, respondents were asked how they would evaluate the application of digitalization solutions on their agricultural holdings, in relation to the desired state. The following 1-5 response scale was offered: (1) I am not satisfied; (5) I am extremely highly satisfied. The average rating is only 2.5, which indicates that the surveyed managers do not show a high degree of satisfaction with the achieved level of digitalization on the farm. As many as 47.2% of agricultural managers rated 1 or 2, while 52.8% of respondents gave ratings from 3 to 5. The obtained results indicate a pronounced polarity on this issue. At the same time, the average rating of managers' satisfaction with the achieved degree of farm digitalization was not significantly different between the group of 16 large farms, which cultivate 20 and more hectares (average rating 2.7) and the group of 37 small and medium-sized farms that cultivate up to 20 ha (average rating 2.6).

Economic sustainability of investments in digitalization solutions on the farm: views of interviewed agricultural managers

The analysis of the economic sustainability of investments in digitalization on the farm was analysed using a set of questions presented in Figure 3.

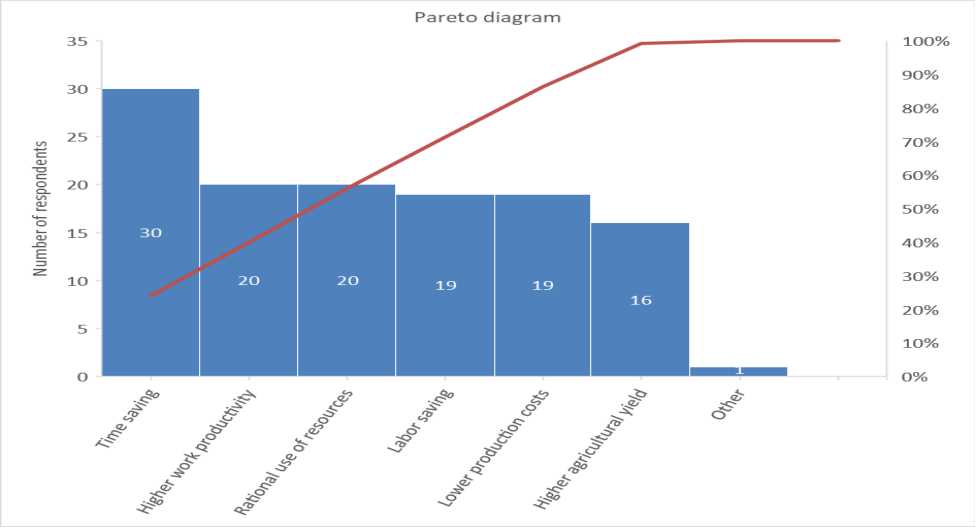
Figure 3. Guide with major issues to be discussed in in-depth interviews with farm managers



Source: Authors' presentation.

When asked what benefits business and production digitalization on the farm brings, the respondents pointed to benefits presented in Figure 4, be they the only benefits or in combination with a set of other benefits. Based on Figure 4, Pareto analysis is useful and indicative due to 80% of the results suggest five main benefits of the digitalization on the agricultural farm (time saving, higher work productivity, rational use of resources, labour saving, and lower production costs).

Figure 4. Benefits of digitalization on the agricultural farm, number and percentage of responses

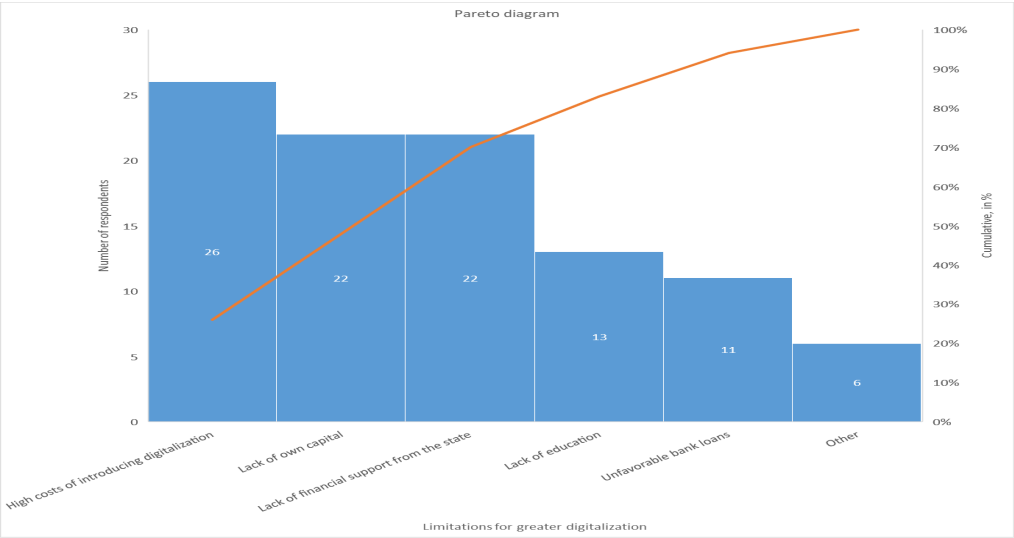


Source: Authors' presentation based on respondents' answers

As for costs that arise when introducing digital agriculture on the farm, respondents mentioned high costs, mainly for: (a) procurement of machinery, equipment, devices, applications; (b) installation of equipment, implementation and maintenance of digital systems; (c) Internet, as well as (d) training to master techniques of managing digitalization devices.

Respondents stated the biggest limitations for greater digitalization on the farm giving answers shown in Figure 4. Respondents pointed to the presented limitations either as the only limitations or in combination with other types of limitations. Based on Figure 5, Pareto analysis is useful and indicative due to 80% of the results suggest four main limitations for greater digitalization on the agricultural farm (high costs of introducing digitalization, lack of own capital, unfavourable bank loans, and lack of financial support from the state).

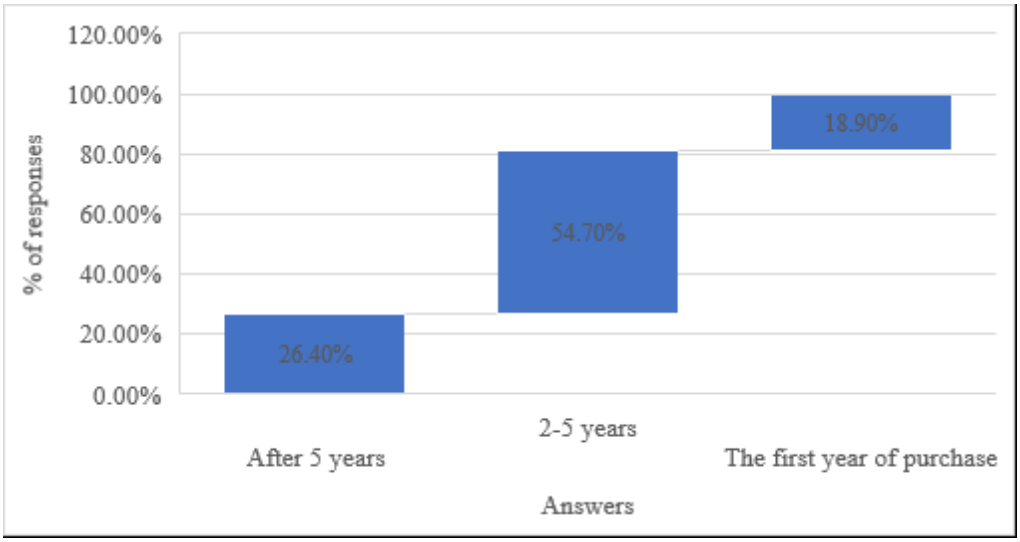
Figure 5. The biggest limitations for greater agricultural digitalization: number and percentage of responses



Source: Authors' presentation based on respondents' answers

For more than half of respondents (54.7%) investment in digitalization is profitable in a period of 2-5 years, for 26.4% of respondents the invested funds return after five years, and for almost 20% of them (18.9%) investment in business digitalization is profitable already in the first year (Figure 6).

Figure 6. Return period of invested funds: percentage of responses

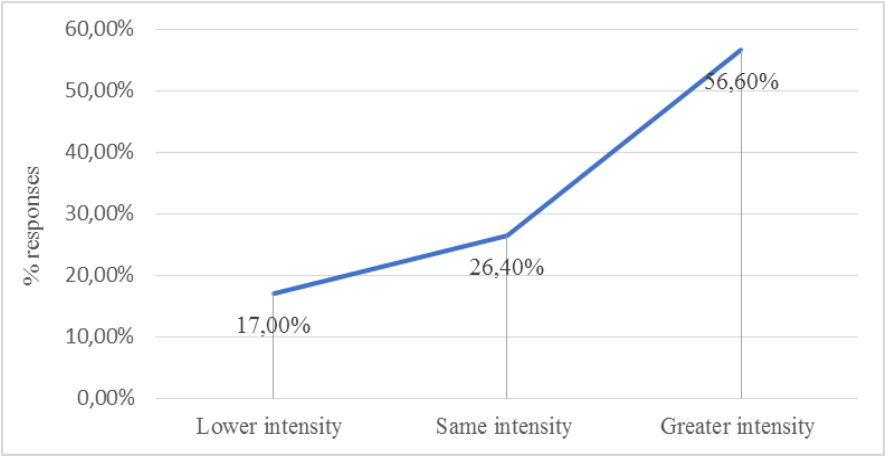


Source: Authors' presentation based on respondents' answers

Respondents evaluated financial support from the relevant ministry and local authorities for greater business and production digitalization giving answers from 1 (not satisfied) to 5 (extremely highly satisfied). As many as 69.8% of respondents rated 1 (not satisfied) or 2 (slightly satisfied), so it can be concluded that farmers are mostly dissatisfied with this type of assistance. Regarding their own activity in finding different support programs (EU support, national support programs, etc.) to finance investments in business and production digitalization, the respondents were divided: 43.4% of them declared that they were not active or were only slightly active, compared to 56.6 % who consider themselves to be moderately to extremely highly active.

In accordance with all the previous answers, and bearing in mind the degree to which investments in digitalization on the farm are economically justified and sustainable, the interviewed agricultural managers declared how intensively they intend to continue with the application of digital solutions on the farm in the future. The results show that more than half of the surveyed agricultural managers (56.6) plan more intensive investments in digitalization in the coming period. 26.4% of them will not change the intensity of investment when it comes to digitalization, while 17% of them will not invest in digitalization or will invest less, due to the low economic sustainability of these investments (Figure 7).

Figure 7. Expected intensity of digitalization on the farm in accordance with the interviewed managers' perceptions about the economic sustainability of investment, % of responses



Source: Authors' presentation based on respondents' answers

The obtained results correspond largely with the results of other authors dealing with this issue. Thus, Latif Virk et al. (2020) and Kernecker et al. (2020) indicate that, today, in general, farmers (in all countries of the world) hesitate to adopt new technologies and digitalize their farms, both because of the high costs they incur in this process, and because of the unavailability of the Internet or the lack of appropriate knowledge and skills. When it comes to digitalization research in Serbian agriculture, the limitations for greater digitalization that authors identified in this research are almost identical to the limitations already established by other authors (Jurjević et al., 2019; ITU & FAO, 2020; Kovljenić et al., 2023). Thus, Jurjević et al. (2019) indicate that insufficient knowledge and education of farmers, along with their low financial strength, are the main reasons that hinder greater digitalization of domestic agriculture, which is why Serbia lags significantly behind the EU countries in this segment. As the reasons for the low rate of adoption of innovations and subsequent technologies in Serbian agriculture, the ITU & FAO (2020) report emphasizes high costs of acquiring appropriate equipment, with state subsidies being of crucial importance for the adoption of new technologies. Also, based on the research of 46 agricultural farms on the territory of Vojvodina, a group of authors (Kovljenić et al., 2023, p. 583) indicates 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*".

Digitalization is a very powerful tool for efficient use of resources and their management in agriculture (Latif Virk et al. 2020). Its positive impact on the sustainability of agriculture is undeniable, and the goals of modernization and technological and digital transformation of Serbian agriculture cannot be achieved in the short term (Jurjević et al., 2019). In order for the farmer to become familiar with the importance of digitalization and start using it, it is important to engage many state and non-governmental

organizations, as well as every individual in promoting new technologies. It is very important that agricultural producers prepare and accept digitalization by mastering new ICT skills and abilities (Pogorelskaia & Várallyai, 2020), and it is also important to adapt digitalization software for use by agricultural producers. In addition, the line ministry's intervention should include surveys, experiments and cost analysis of digital production, in order to increase farmers' confidence for further and more intensive digitalization (ITU & FAO, 2020). Finally, creating an enabling environment for the transition of agricultural systems towards greater automation and digitalization implies multiple and coherent actions, including legislation and the adoption of appropriate regulations, infrastructure, institutional arrangements, education and training, as well as research and development (FAO, 2022).

Although the answers obtained by the interview have a high degree of validity and relevance, the biggest research limitation lies in the subjectivity of respondents' views, which is, after all, a peculiarity of most social research, which is difficult to avoid (Shipman, 2014).

The research represents a valuable basis for further and more extensive scientific and empirical research. The next steps could certainly be to upgrade the obtained results and examine the environmental and social dimensions of sustainability of agricultural digitalization. Also, it would be useful to analyse the quality and availability of training and education programs for farmers, which is extremely important for their business, as well as any other training in the new digital age.

Conclusions

With the primary goal of gaining empirical knowledge about the economic aspects of digitalization on agricultural farms in Serbia, the authors interviewed 53 agricultural producers (managers), using a semi-structured questionnaire. The survey resulted in the following conclusions: (a) the largest number of farms have land holdings of 1-5 ha, on which they apply some digital solutions, engage in mixed agricultural production and have one employee on their farm; (b) from digital solutions in agriculture, the largest percentage of producers use the Internet (to obtain knowledge and information about agriculture, the market, incentives, etc.); a significantly smaller number of interviewed managers declare that they use some of the more advanced digital solutions in their business and production processes; (c) 60.4% of respondents replaced work and production processes by digital solutions only up to 10%, while the smallest number of respondents replaced their work processes with digital solutions 50-70%; (d) the largest number of producers apply digital solutions during soil cultivation, sowing, fertilizing, irrigation and crop protection, mostly in farming and vegetable growing.

The economic aspects of digitalization of Serbian agriculture, based on the results of the interviews, indicate the following: (a) as for the greatest benefits of digitalization, the interviewees cited time savings, followed by higher labour productivity, lower production costs, labour savings, rational use of resources, higher yields and other;

(b) the highest digitalization costs relate to the procurement of machinery, equipment, devices, applications; then implementation and maintenance of digital systems; as well as training to master digital devices; (c) the biggest limitations for greater digitalization are high investments, as well as the lack of own capital and financial support from the state; (d) farmers are relatively satisfied with their own activity in finding different support programs for financing digitalization investments; at the same time, they are very dissatisfied with the financial support provided for these purposes by relevant ministries and local authorities; (e) the largest percentage of agricultural managers (55%) manage to return the funds invested in the digitalization of agriculture within a period of 2 to 5 years.

The general conclusion is that digitalization is applied in the agricultural sector of Serbia, but in a careful, questioning, modest way, with a tendency to intensify in the coming period. The "digital age" can be used to the maximum in the agricultural sector, by introducing advanced digital solutions, which will improve certain stages of the agricultural production cycle, improve sustainability and profitability of production, while simultaneously ensuring a sufficient amount of quality agricultural products and preserving the environment.

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Conflict of interests

The authors declare no conflict of interest.

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