Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 24, Issue 3, 2024
PRINT ISSN 2284-7995, E-ISSN 2285-3952

SOCIO-ENVIRONMENTAL ASPECTS OF DIGITALISATION IN SERBIAN AGRICULTURE: FARMERS' PERCEPTIONS

Nataša KLJAJIĆ, Vesna PARAUŠIĆ, Jonel SUBIĆ

Institute of Agricultural Economics in Belgrade, Volgina 15, Belgrade, Serbia, Phone/Fax: +381(0)116972858; E-mails: natasa_k@iep.bg.ac.rs, vesna_pa@iep.bg.ac.rs, jonel_s@iep.bg.ac.rs

Corresponding author: natasa_k@iep.bg.ac.rs

Abstract

The authors examine the opinions of agricultural producers in Serbia about the impact of digitalisation in agriculture on the socio-environmental dimension of agricultural sustainability and the overall development of the country. Empirical data were collected through a semi-structured questionnaire and an interview with 53 producers who apply some of digital solutions on their farms. The research was conducted during a six-month period in 2023 (April – October). Responses to most questions regarding the social dimension of sustainability indicate some polarisation of opinions, as well as certain doubt about the contribution of digitalisation to this sustainability dimension. A unique and positive attitude is noticeable only in the assessment of the contribution of digitalisation to the reduction of the engaged labour force in agriculture and to the possibilities for greater diversification of farmers' activities into various non-agricultural sectors. On the other hand, the respondents' answers clearly show their positive perception of the contribution of digitalisation in production to the ecological aspects of agriculture and to the overall improvement of the environment. The largest percentage of the surveyed farmers' recommendations for greater implementation of digitalisation in agricultural practices refer to directing more funds to subsidies and other forms of financial support, as well as to educating producers about digitalisation.

Key words**:** *agricultural digitalisation, Serbia, socio-environmental sustainability, perception, recommendations*

INTRODUCTION

The global population is growing rapidly and it is estimated to reach about 10 billion by 2050 [33, 1]. According to [2], the agricultural production has to be increased by 70% compared to the current situation in order to feed the global population. However, estimates show that the current tendency of the food production increase is much below the projected requirements of the growing world population [5, 22].

Concerns about food security and food provision at a global level have led to a series of new solutions aimed at maximising productivity in agriculture. Among these, the solutions within Agriculture 4.0 or in the field of digitalisation of production and business processes are becoming increasingly relevant. Digitalisation represents a set of diverse digital tools and applications, i.e. mutually connected digital technologies which participate in the agricultural production process. These technologies are based on business automation, use of electronics, robotics, computers, telecommunications, genetic engineering, artificial intelligence and communication technologies, as well as various applications used for processing large quantities of data, in addition to other existing technologies such as smartphones, satellites, the Internet of Things and alike [17, 7, 29, 23, 14].

The implementation of digitalisation in agriculture brings greater productivity and profitability of production, lowers costs and losses, while simultaneously helping to preserve the environment and achieve environmental and social sustainability [15, 18, 4, 12, 29, 14, 28, 20]. Digital technologies enable the automation of production processes, monitoring of the quantitative characteristics of soil and crops, crop rotation management, i.e. supervising the complete production cycle of a crop from planting to harvest. In this manner, it is possible to accurately determine when it is necessary to intervene in agricultural processes (ploughing, irrigation, fertilisation, pesticide treatments) in accordance with the condition of the soil, the current phenophase of the plants and values of climatic parameters

[21, 35, 30, 24]. The main benefits of the digital transformation of agriculture are the increasing sustainability, knowledge and production efficiency [31].

Although Serbia has considerable potential resources for diverse agricultural production, there are numerous limiting factors for greater productivity and efficiency. They mainly refer to the fragmentation of land holdings, low economic power of agricultural farms, unfavourable age and educational structure of farmers, as well as low and inconsistent support from agricultural policies [26, 10, 25, 34]. These factors also lead to an insufficient use of the potentials of the application of digital technologies in Serbia, despite the fact that these technologies offer a wide range of creative solutions and benefits to business. Digital solutions are rarely implemented primarily because they are financially inaccessible for average farmers, who also lack information about the advantages of applying these solutions [19, 15, 13, 20]. More advanced and larger-scale farmers mainly choose partial solutions related to remote irrigation systems. Installing digital meteorological stations and sensors is mainly experimental. The following technologies of precision agriculture are most commonly used in Serbia: (a) recording/inspection/control of plot conditions using drones; (b) using satellite recordings and monitoring crop conditions; (c) using different software for estimating and assessing the state of land and crops before and after planting, fertilisation, chemical protection, inter-row cultivation; (d) using automatic systems for regulating and adjusting passageways of tractors and towed vehicles; (e) applying sensor networks and software for the real-time monitoring of changes in soil, crops, climate and similar factors [27].

The subject of the authors' research is examination of the opinions of agricultural producers in Serbia about the socio-environmental component of the sustainability of investments in the digitalisation of production and business processes in agriculture. In addition, the authors studied and analysed farmers' recommendations on how to expand the digitalisation process in Serbian agriculture and make digital solutions more accessible to average, small-scale farmers. The research aims are directed towards acquiring empirical knowledge and better understanding of the analysed topic, which is still insufficiently represented in the scientific and professional literature. The obtained findings will significantly enrich the scientific literature in this field and will have practical importance for agricultural extension services, agricultural producers, as well as agricultural policy makers in Serbia.

MATERIALS AND METHODS

In order to obtain the perceptions of farmers on the socio-environmental dimension of investments in digital solutions (abbr. DSs) in agriculture, the authors conducted a qualitative study using the methods of an interview and semi-structured questionnaire [16].

The sample included 53 farmers who apply some types of DSs in their production and business processes. A certain number of the respondents were interviewed over the telephone, with conversations lasting from 45 to 60 minutes. Responses of the other part of the respondents were collected directly through fieldwork and face-to-face conversations with producers. The research was conducted in the territory of the Republic of Serbia from April to October 2023, which made the sample territorially representative.

The questionnaire included the following questions relevant to investigating social aspects of the sustainability of investments in digitalisation in agriculture:

(1)Will a greater application of digitalisation in agriculture lead to a reduction in the engagement of labour force in agriculture and its redirection to other non-agricultural activities? Response options: yes; no; partially;

(2)Will a greater application of digitalisation in agriculture led to stopping the departure of young people from rural areas? Response options: yes; no; partially;

(3)Does the local community ensure effective transfer of knowledge and information about DSs to farmers? Response options: yes; no; partially;

(4)How satisfied are you with the cooperation of key stakeholders in this area (the government, economic sector, universities and institutes, banks, agricultural extension services, farmers and others)? Response options: 1 (not satisfied); 2 (slightly satisfied); 3 (satisfied); 4 (highly satisfied); 5 (extremely satisfied).

The questionnaire also involved the following questions relevant to investigating the environmental aspects of the sustainability of investments in digitalisation on farms:

(i)Does the application of DSs in agriculture lead to the reduced consumption of energy and chemicals in agricultural production? Response options: yes; no; partially;

(ii)How does the implementation of DSs in agriculture affect the environment, society's fight with climate change and global pollution? Response options: positively; negatively; neutral.

In order to obtain a comprehensive view of the respondents' opinions about the research subject, the questionnaire also included the question regarding farmers' recommendations to the government and producers of machinery, equipment and software in digital agriculture related to making the implementation of DSs more accessible to average, small-scale farmers.

All responses were objectively analysed and presented using descriptive and synthesis methods.

RESULTS AND DISCUSSIONS

The results of the research are presented through the description of the sample structure, followed by the respondents' opinions about the socio-environmental sustainability of investments in different DSs in agriculture.

Sample description

The sample included 53 respondents, i.e. 53 holders of registered agricultural holdings in the territory of Serbia. Within the sample, 44 respondents were holders of family farms, 7 were managers of agricultural companies, while one respondent was registered as an entrepreneur and one as a manager of an agricultural cooperative. The respondents were distributed across 19 areas throughout the territory of the Republic of Serbia.

The largest percentage of the respondents cultivates the land area ranging from 5 to 20 ha (20 respondents or 37.7%). These are followed by 18 respondents (34%) cultivating small holdings (up to 5 ha), then 9 respondents (17%) cultivating the area ranging from 20 ha to 100 ha and only 6 farmers (11.3%) cultivating more than 100 ha of land. On the largest number of farms (64.2%) up to two individuals are involved in the production, while on a smaller number of farms (30.2%) three to five people are involved in the agricultural production process. The majority of the respondents engage in mixed agricultural production on their farms (34%). The respondents specialising in crop growing constitute 32.1% those specialising in fruit growing and/or viticulture account for 18.9%, while the respondents specialising in animal husbandry constitute 15.1%.

The interviewed agricultural producers apply various forms of digitalisation in the process of agricultural production and business. Out of the total number of the respondents, the largest percentage (55%) use the Internet in their production as a digital solution for collecting information and news about agriculture, market, incentive measures, etc. A significantly smaller number of the interviewed farmers state that they use some of more advanced solutions in the digitalisation of business and production processes (automatic systems for regulating and adjusting passageways of tractors and towed vehicles; satellite recordings and commercial drones for monitoring crop conditions; probes and sensors for soil sampling and irrigation control).

The production processes have been replaced with DSs to different degrees on the farms of the interviewed agricultural producers. The largest number of them (60.4%) has replaced production and business processes with DSs by up to 10%, while the fewest number of the respondents (7.6%) have replaced their production and business processes with DSs by more than 50%.

The surveyed agricultural producers apply some forms of DSs on their farms in the following business and production processes:

(a) soil tillage including planting, fertilisation, irrigation and phytosanitary protection; (b) greenhouse heating and related automatic processes in greenhouses; (c) measuring and supervising the production; (d) selling products; (e) obtaining information about the market and about subsidies and incentive measures.

The respondents mentioned numerous benefits of digitalisation, the most significant being: (a) savings related to engaged labour force and time; (b) higher work productivity; (c) rational use of resources (water in the irrigation process, fertilisers, and seeds) and lower production costs; (d) higher yield of agricultural crops. At the same time, the respondents underlined numerous limitations in the process of DS implementation on their farms, among which the most significant were high costs of acquiring/implementing/installing and/or maintaining digital systems, equipment and devices.

Social aspects of the sustainability of investments in digitalisation in agriculture: views of the surveyed farmers

Social aspects of the sustainability of investments in different DSs on the farms were analysed using the four questions from the Questionnaire mentioned in the Materials and Methods section. The processing of the results obtained in the research is presented in the following text.

Question 1. Graph 1 shows that as many as 29 respondents, or 55%, think that digitalisation leads to a reduction in the number of workers and number of working hours in agriculture. This creates possibilities for redirecting the labour force to other non-agricultural activities (diversification of activities towards processing, rural tourism or other forms of engagement in the local community, due to time savings and reduced involvement in agricultural activities during and outside the vegetation period). At the same time, 17 respondents (32%) answered "partially", while only 7 respondents (13%) do not believe that greater digitalisation on the farm will reduce the engagement of labour force in agriculture and enable its redirection to other non-agricultural activities (Figure 1).

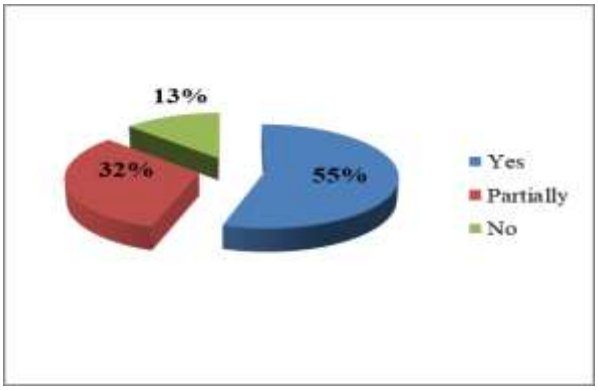

Fig. 1. Will a greater application of digitalisation in agriculture lead to a reduction in the engagement of labour force in agriculture and its redirection to other non-agricultural activities? (%)
Source: Producers' responses.

Question 2. The issues of insufficient labour force in agriculture and depopulation in rural settlements (caused mainly by migrations to urban centres due to higher earnings and better employment possibilities) are becoming increasingly concerning in Serbia and other countries in the region [11].

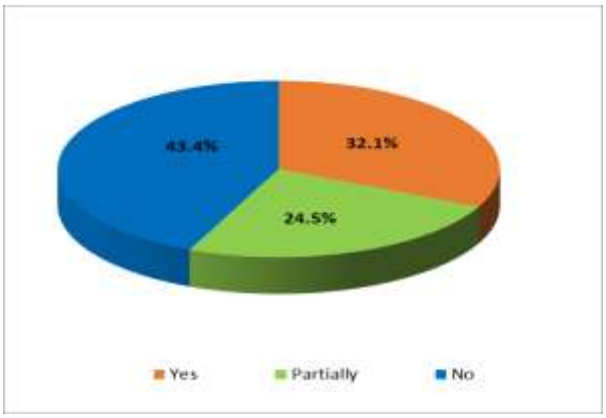

Fig. 2. Will a greater application of digitalisation in agriculture leads to stopping the departure of young people from rural areas? (%)
Source: Producers' responses.

Figure 2 shows that the respondents do not have a unanimous response to the question whether digitalisation in agriculture contributes to stopping the departure of young people from rural areas. However, the opinion of farmers about this aspect of digitalisation cannot be estimated as overly optimistic, since 23 respondents, or 43%, believe that a greater application of DSs on farms will not stop the departure of young people from rural areas. Approximately one third of the respondents (17 respondents, or

32%) have an opposite attitude – they believe that greater digitalisation in agriculture will contribute to stopping the departure of the young from rural areas. Thirteen farmers (or 25%) could not decisively express their opinion on this question (Figure 2).

Question 3. In response to the question whether they are satisfied with the manner in which the local community ensures the transfer of knowledge and information about DSs to farmers, 26.4% of the respondents stated that they were satisfied, while 43.4% of them provided a negative answer (Fig. 3).

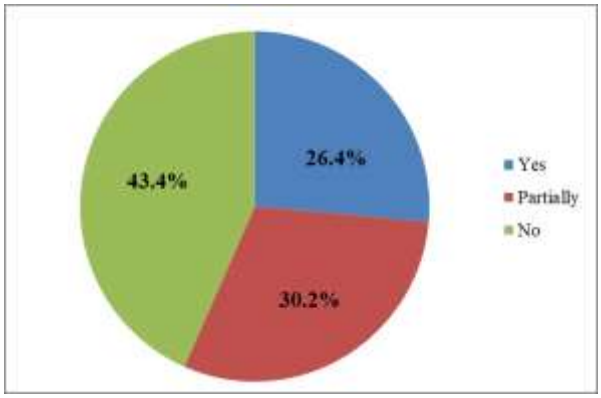

Fig. 3. Does the local community ensure effective transfer of knowledge and information about DSs to farmers? (%)
Source: Producers' responses.

It is obvious that the respondents do not have a unified stance regarding this question. However, it is evident that a significant percentage of the interviewed farmers are not satisfied (43.4%) or are only partially satisfied (30.2%) with the measures and activities undertaken by the key local stakeholders (agricultural extension officers, representatives of local authorities, local media, companies producing digital solutions and other stakeholders) with the aim of making knowledge and information about digital agriculture accessible to average agricultural producers (Fig. 3). The research shows that farmers in Serbia are aware of the fact that the implementation of digitalisation in production and business can have numerous benefits. Still, in most cases they do not completely understand the way of introducing and managing digitalisation.

There are numerous tools which can be useful on a farm and are available to everyone and can be obtained at affordable prices. These are primarily mobile applications which are most commonly free, and which can be used for crop monitoring and alerting in case of nutrient deficit or diseases. In addition, there are free GIS platforms for PCs where geospatial data from various sensors can be used. Sensor detection is becoming increasingly accessible. Both close-range and remote detection enable timely detection of problems on the plot. However, due to the low level of digital literacy in rural areas, low education level of farmers and their small economic power, Serbia lags behind the EU countries in the process of agricultural digitalisation [15, 13, 20]. These circumstances require the urgent creation of suitable advisory and educational programmes through which IT professionals, agricultural extension officers and other stakeholders might support farmers. This will consequently result in certain progress in this area [15, 20, 36].

Numerous authors highlight the significance of education and efficient transfer of digital knowledge and skills to farmers, stating that only in this manner can the digital divide between the inhabitants of rural and urban areas be overcome. In this way, various digital solutions will be represented even on agricultural holdings of medium and small-scale farmers [29, 3].

Question 4. When asked if they are satisfied with the cooperation between the key stakeholders (the government, private sector, universities and institutes, banks, agricultural extension services, farmers and others) in the sector of development, application and dissemination of knowledge from DSs to farmers, as many as 31 farmers (58.5%) stated that they were dissatisfied or slightly satisfied with the cooperation. On the other hand, 22 respondents, or 41.5%, were satisfied, highly satisfied or extremely satisfied (Fig. 4.).

Despite the benefits that digitalisation offers to agricultural producers, it also creates the so-called digital divide between agricultural producers and other market participants that have an access to the most modern technologies in this production process and those who do not [29, 6]. In order to decrease this divide and enable an equal access to

digitalisation for everyone, private efforts of companies in the digitalisation sectors and intelligent and constructive public policies should be combined [6]. This cooperation between the private sector and governmental authorities should result in an "agricultural revolution". It would bring benefits to all farmers, agricultural workers, and consumers, as well as the environment worldwide, while efficiently managing the threats of market concentration [6].

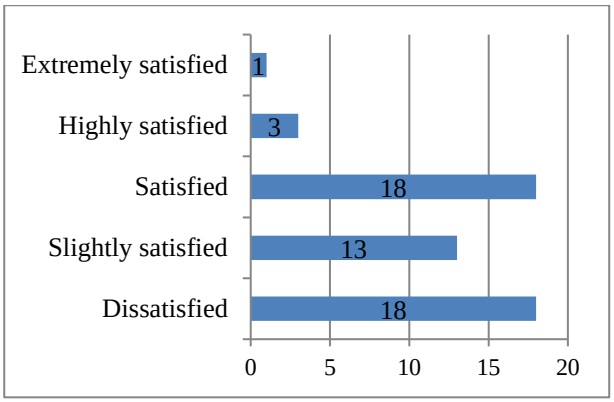

Fig. 4. How satisfied are you with the cooperation of key stakeholders in this area (the government, economic sector, universities and institutes, banks, agricultural extension services, farmers and others) in the segment of development, application and dissemination of knowledge from DSs to farmers? Number of responses.
Source: Producers' responses.

It is important for the government, private sector, faculties and institutes, banks and other stakeholders in Serbia to cooperate on providing educational and financial support to all agricultural producers in the field of digitalisation, regardless of their physical or economic size or power. Only in this manner can the agricultural sector completely benefit from the new digitalisation era, by improving the sustainability and profitability of agricultural activities, while simultaneously solving current issues related to climate change and food security.

Environmental aspects of the sustainability of investments in digitalisation in agriculture: views of the surveyed farmers

Question 1. When asked whether the implementation of DSs in agriculture leads to the reduced consumption of energy and chemicals in agricultural production, as many as 71% of the respondents provided an affirmative response (Fig. 5). Having in mind that 17% of the respondents believe that digitalisation partially contributes to these savings, it can be concluded that a vast majority of the respondents showed a positive stance on this question.

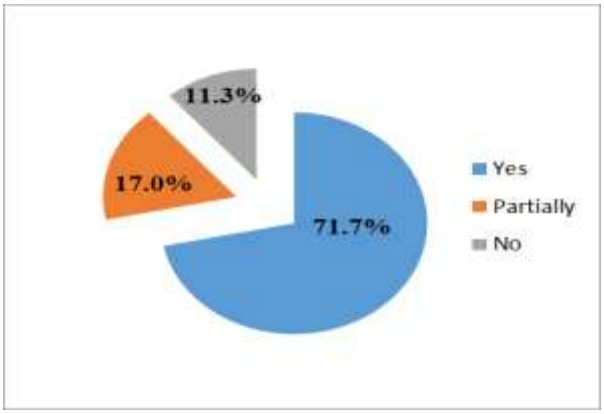

Fig. 5. Does the application of DSs in agriculture lead to the reduced consumption of energy and chemicals in agricultural production? Response structure, %
Source: Producers' responses.

Question 2. The examination of the attitudes about the contribution of digitalisation in agriculture to the improvement of the environment shows that as many as 60.4% of the respondents think that digitalisation can help society fight climate change, global pollution and global warming, and that it has a positive impact on the improvement of the environment (Fig. 6.). At the same time, around 40% of the respondents do not associate digitalisation with the improvement of the environment. Still, none of the respondents has a negative opinion on this issue (Fig. 6).

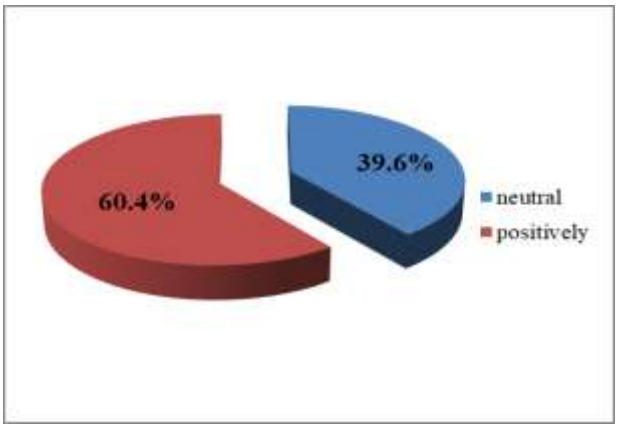

Fig. 6. The contribution of digitalisation in agriculture to the improvement of the environment. Response structure, %.
Source: Producers' responses.

A study by a group of authors [7] also indicates that digitalisation in agriculture has a positive impact on the reduction of water or pesticide consumption in production, as well as on the more efficient efforts of society made against climate change.

Recommendations of farmers to the government and producers of machinery, equipment and software in the field of digitalisation related to making the implementation of DSs more accessible to average, small-scale farmers in the future.

Farmers' recommendations are predominantly directed towards the following types of support:

-Greater governmental subsidies for the acquisition of machinery, equipment, digital devices, various applications and digital platforms that support the transformation of agriculture towards precision agriculture. The greatest number of the respondents believe that it is of utmost importance for the government to provide some form of financial support for innovative tools from the field of digitalisation;

-Education, training, practical lectures on digital technologies and digital literacy (training seminars at the local community level; more direct communication with farmers in order to introduce them to digital solutions and the advantages of digital agriculture; accompanying video content for each purchased software and alike). Approximately 15% of the respondents believe that education is a necessary condition for the digitalisation of agriculture since these technologies are complex, require comprehensive knowledge from various fields, while the implementation effects are not clear;

-Reducing the prices of the equipment and devices in the field of digital technologies;

-Adapting software to the needs and intended uses of the users (farmers);

-More favourable bank loans for purchasing digital hardware and software.

The document ITU & FAO [13] contains similar recommendations, and highlights that, due to the poor development of digital infrastructure and high costs of acquiring digital equipment, the governmental support in the form of subsidies is of utmost importance for the adoption of new technologies in rural areas of Serbia.

Another group of authors [6] also underlines the significance of public efforts made for greater digitalisation of agriculture. They state that in developing countries public efforts should help transform numerous positive effects of digital agriculture from the private sector into sustainable practices and extend their benefits to a larger number of farmers and consumers. As these authors state, "*interventions that have promise include policies for an enabling business environment, developing knowledge and skills, providing communication infrastructure and financing applied research in support of digital technologies"* [6, p. 1281]. In addition, public policies are not only required for using the possibilities and advantages provided by digital agriculture, but also for dealing with its potential threats, such as increasing the digital divide between farmers, increasing concentration in the agricultural input industry or expanding the market power of large agribusiness companies [6]. Finally, the FAO document from 2022 [9] highlights that the creation of a favourable environment for the transition of agricultural systems towards greater automation and digitalisation involves multiple coherent actions, including legislation and adoption of appropriate regulations, development of comprehensive infrastructure and institutional arrangements, education and training, and research and development.

Although the responses obtained by the interview method reached a high degree of validity and relevance, the greatest limitation of the conducted research in this paper is the subjective opinion of the interviewed farmers. Nevertheless, subjectivity is difficult to avoid and remains present in most social studies [32]. Studying the social and environmental dimension of sustainability of agricultural digitalisation can be a solid base for more comprehensive future research by authors in the mentioned field. Further research might also be directed towards analysing available training and education programmes for farmers in the field of digitalisation, as well as towards the empirical analysis of specific effects of digitalisation on agricultural holdings (best

practice examples) while applying the case study method.

CONCLUSIONS

Digital technology is having an increasingly strong impact on the socio-economic development and environmental sustainability of the Republic of Serbia. Thus, it has become the area of growing interest of the academic community and social community. Digitalisation of agriculture is one of the most important tasks which are to be implemented in the future with the aim of creating a more profitable, cost-effective and environmentally and socially sustainable agricultural production. However, due to the slow progress of Serbia in the digitalisation of business and production processes in agriculture, it is obvious that the set aims of modernisation and technological and digital transformation of agriculture cannot be quickly realised [15].

Considering that the academic community has a unique stance regarding the positive contribution of agricultural digitalisation to sustainable development, the authors of the paper examined the perceptions of farmers in Serbia about the impact of digitalisation in agriculture on socio-environmental dimensions of sustainability. Using the interview method, the authors collected the perceptions of 53 producers who apply some digital solutions in their business.

When it comes to the social dimension of the sustainability of investments in digital solutions on agricultural households, the results show the following: (a) a large majority of the interviewed farmers (87%) believe that investments in digitalisation lead (completely or partially) to a reduction in the number of engaged agricultural workers, which enables the redirection of labour force to other non-agricultural activities; (b) the respondents do not have a unanimous opinion about the contribution of digitalisation in agriculture to stopping the departure of young people from rural areas, but the general farmers' attitude on this issue is not overly optimistic (43.3% of the respondents think that a greater application of digitalisation on agricultural holdings will not stop the departure of the young from rural areas); (c)) the respondents are also not overly optimistic regarding the question asking whether the local community ensures an effective transfer of knowledge and information about digital solutions to agricultural producers (as many as 73.6% of the respondents are dissatisfied or partially satisfied with the measures and activities undertaken by the key local stakeholders in order to make knowledge and information about digital agriculture closer to average agricultural producers); (d) when asked how satisfied they are with the cooperation between the key stakeholders in the segment of development, application and dissemination of knowledge, the respondents provided polarised responses (58.5% respondents were dissatisfied or slightly satisfied with this cooperation, compared to 42.5% who were satisfied with this cooperation).

When it comes to the respondents' opinions about the environmental dimension of the sustainability of digitalisation on the farm, the results unequivocally show that a vast majority of the respondents think that digitalisation leads to the reduced consumption of energy and chemicals, and that it can help society combat climate change, global pollution and global warming.

The farmers' recommendations to the government authorities and producers of machinery, equipment and software in the field of digitalisation refer mainly to the necessity of greater subsidies from the government and the development of education, training and practical lectures about digital technologies and digital literacy, all in order to make digital solutions accessible to average, small-scale farmers.

ACKNOWLEDGEMENTS

Paper is part of research financed by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, agreed in decision no. 451-03-66/2024-03/200009 from 5.2.2024.

REFERENCES

[1]Abbasi, R., Martinez, P., Ahmad, R., 2022, The digitization of agricultural industry-a systematic

literature review on agriculture 4.0 in Smart Agricultural Technology, 2, 100042. https://doi.org/10.102300016/j.atech.2022.100042

[2]Alt, V., Isakova, S., Balushkina, E., 2020, Digitalization: problems of its development in modern agricultural production in E3S Web Conference, Vol. 210: 10001, EDP Sciences, https://doi.org/10.1051/e3sconf/202021010001

[3]Anastasiou, E., Manika, S., Ragazou, K., Katsios, I. 2021, Territorial and human geography challenges: How can smart villages support rural development and population inclusion? in Social Sciences, 10(6): 193. https://doi.org/10.3390/socsci10060193

[4]Atanga, S. N., 2020, Digitalization of agriculture: How digital technology is transforming small-scale farming in Ghana in Agrarian, Food and Environmental Studies (AFES). A research paper submitted to Erasmus University in partial fulfilment of the requirements for the degree of Master of Arts in Development Studies at the International Institute of Social Studies, 1-53. http://hdl.handle.net/2105/55705

[5]Bertoglio, R., Corbo, C., Renga, F. M., Matteucci, M. 2021, The digital agricultural revolution: a bibliometric analysis literature review in IEEE Access, 9: 134762-134782. doi DOI: 10.1109/ACCESS.2021.3115258.

[6]Birner, R., Daum, T., Pray, C., 2021, Who drives the digital revolution in agriculture? in A review of supplyside trends, players and challenges in Applied economic perspectives and policy, 43(4): 1260-1285. DOI: https://doi.org/10.1002/aepp.13145

[7]Ciruela-Lorenzo, A. M., Del-Aguila-Obra, A. R., Padilla-Meléndez, A., Plaza-Angulo, J. J., 2020, Digitalization of agri-cooperatives in the smart agriculture context. Proposal of a digital diagnosis tool in Sustainability, 12(4): 1325. https://doi.org/10.3390/su12041325

[8]Dobre, I., Capra, M., Costache, C., Dorobantu, N., 2021, Farm size and digitalization: Quantitative approach. Western Balkan Journal of Agricultural Economics and Rural Development (WBJAERD), 3(1): 67-83, doi: 10.5937/WBJAE2101067D

[9]FAO, 2022, The State of Food and Agriculture 2022. Leveraging automation in agriculture for transforming agrifood systems. Rome, FAO. https://doi.org/10.4060/cb9479en

[10]FAO, 2020a, Smallholders and family farms in Serbia. County study report. 2019. Budapest. Food and Agriculture Organization of the United Nations Budapest, 2020. DOI: https://doi.org/10.4060/ca7449en

[11]FAO, 2020b, Empowering Smallholders and Family Farms in Europe and Central Asia. Regional Synthesis Report 2019 based on country studies in eight countries in Europe and Central and Asia. Food and Agriculture Organization of the United Nations: Budapest, 2020. https://doi.org/10.4060/ca9586en

[12]Faskhutdinova, M., S., Amirova, E. F., Safiullin, I. N., Ibragimov, L. G., 2020, Human resources in the context of digitalization of agriculture in BIO Web of Conferences, Vol. 27: 00020, EDP Sciences, https://doi.org/10.1051/bioconf/20202700020

[13]ITU & FAO, 2020, Status of Digital Agriculture in 18 countries of Europe and Central Asia. Geneva, Switzerland. https://www.fao.org/3/ca9578en/CA9578EN.pdf, Accessed on 15 Feb. 2024.

[14]Javaid, M., Haleem, A., Singh, R. P., Suman, R., 2022, Enhancing smart farming through the applications of Agriculture 4.0 technologies in International Journal of Intelligent Networks, 3: 150-164. https://doi.org/10.1016/j.ijin.2022.09.004

[15]Jurjević, Ž., Bogićević, I., Đokić, D., Matkovski, B., 2019, Information technology as a factor of sustainable development of Serbian agriculture in Strategic management, 24(1): 41-46. DOI:10.5937/StraMan1901041J

[16]Kallio, H., Pietilä, A. M., Johnson, M., Kangasniemi, M., 2016, Systematic methodological review: developing a framework for a qualitative semistructured interview guide in Journal of advanced nursing, 72(12): 2954-2965, https://onlinelibrary.wiley.com/doi/pdf/10.1111/jan.13031 Accessed on 28 Nov. 2023.

[17]Kashapov, N. F., Nafikov, M. K.H., Gazetdinov, S.H. M., Gazetdinov, A. R., Nigmatzyanov, A. R., 2019, Modern problems of digitalization of agricultural production in IOP Conf. Series: Materials Science and Engineering 570, 012044, doi:10.1088/1757-899X/570/1/012044

[18]Klerkx, L. Jakku, E., Labarthe, P., 2019, A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda in NJAS-Wageningen journal of life sciences, 90-91: 100315. https://doi.org/10.1016/j.njas.2019.100315

[19]Kljajić, N., Paraušić, V., Rodić, A., 2016, Techno-economic feasibility uses of portable solar irrigation system, 36-57. In Tomić, D., Lovre, K., Subić, J. and Ševarlić, M. (Eds.) Emerging technologies and the development of agriculture, Thematic Proceedings, 152nd EAAE seminar. Serbian Association of Agricultural Economists, Belgrade, Serbia; Faculty of Economics, Subotica, University of Novi Sad, Serbia; Institute of Agricultural Economics, Belgrade, Serbia, http://repository.iep.bg.ac.rs/id/eprint/299

[20]Kovljenić, M., Škorić, J., Galetin, M., Škorić, S., 2023, Digital Technology in agricuture: evidence from farms on the territory of AP Vojvodina in Economics of Agriculture, 70 (2): 583-596. doi:10.59267/ekoPolj2302583K

[21]Lakota, M., Stanko, D., Vindiš, P., Berk, P., Kelc, D., Rakun, J., 2019, Automatization and digitalization in Agriculture in Poljoprivredna tehnika, 2: 13-22. doi: 10.5937/PoljTeh1902013L

[22]Lioutas, D. E., Charatsari, C., De Rosa, M., 2021, Digitalization of agriculture: A way to solve the food problem or a trolley dilemma? In Technology in Society, 67: 101744. https://doi.org/10.1016/j.techsoc.2021.101744

[23]Mijić, D., Vico, G., Ljubojević, M., 2021, Digitalization of Agriculture in Bosnia and Herzegovina: Current State and Examples of Good

practice in 20th International Symposium INFOTEH-JAHORINA, pp. 1-6, IEEE, https://doi.org/10.1109/INFOTEH51037.2021.9400649
[24]Nezamova, O. A., Olentsova, J. A., 2022, The main trends of digitalization in agriculture in IOP Conference Series: Earth and Environmental Science, 981(3): 032018, IOP Publishing. doi:10.1088/1755-1315/981/3/032018, https://iopscience.iop.org/article/10.1088/1755-1315/981/3/032018/pdf, Accessed on 03 Feb. 2024.
[25]Paraušić, V., Subić, J., Roljević Nikolić, S., 2021, Economic size and structural characteristics of agricultural holdings in the EU and Serbia in L. Chivu, V. Ioan-Franc, G. Georgescu, J. V. Andrei (Eds.), Harnessing Tangible and Intangible Assets in the context of European Integration and Globalization: Challenges ahead, 1027-1039. Berlin, Germany: Peter Lang Verlag GmbH. DOI: 10.3726/978-3-653-06574-9
[26]Paraušić, V., Roljević Nikolić, S., Subić, J., 2019, Anketa o strukturi poljoprivrednih gazdinstava, 2018: poljoprivredna gazdinstva prema tipu proizvodnje i ekonomskoj veličini (Farm Structure Survey, 2018: Farms by Production Type and Economic Size). Statistical Office of the Republic of Serbia. https://publikacije.stat.gov.rs/G2019/Pdf/G20196005.pdf, Accessed on 20 Nov. 2023.
[27]PC Press, 2019, Perspektive poljoprivrede: Preciznost zahvaljujući tehnologiji (Perspectives on agriculture: Precision thanks to technology), 13.06.2019. Available online: https://pcpress.rs/perspektive-poljoprivrede-preciznost-zahvaljujuci-tehnologiji/, Accessed on 23 January, 2024.
[28]Petrović, D., Stanimirović, P., Vratonjić Gligorijević, A., 2022, Značaj projekata digitalne transformacije u poljoprivredi i izazovi njihove ocene opravdanosti in Tehnika (The importance of digital transformation projects in agriculture and the cahhallenges of evaluating their justofocation in Technology), 77.6 (2022), 767-773, DOI: 10.5937/tehnika2206767P
[29]Pogorelskaia, I., Várallyai, L., 2020, Agriculture 4.0 and the role of education in Journal of Agricultural Informatics, 11(1): 45-51, doi: 10.17700/jai.2020.11.1.571
[30]Rolandi, S., Brunori, G., Bacco, M., Scotti, I., 2021, The digitalization of agriculture and rural areas: Towards a taxonomy of the impacts in Sustainability, 13 (9): 5172. https://doi.org/10.3390/su13095172
[31]Shepherd, M., Turner, J.A., Small, B., Wheeler, D., 2018, Priorities for science to overcome hurdles thwarting the full promise of the 'digital agriculture' revolution in Journal of the Science of Food and Agriculture, 100 (14): 5083–5092. DOI: 10.1002/jsfa.9346
[32]Shipman, M. D., 2014, The limitations of social research. Routledge. London doi: https://doi.org/10.4324/9781315840727. https://www.taylorfrancis.com/books/mono/10.4324/9781315840727/limitations-social-research-shipman, Accessed on 12 Nov. 2023.
[33]Subeesh, A., Mehta, C. R., 2021, Automation and digitization of agriculture using artificial intelligence and internet of things in Artificial Intelligence in Agriculture, 5: 278-291. DOI:10.1016/j.aiia.2021.11.004
[34]Šljukić, M., Šljukić, S., Vidicki, V., 2021, Small-Scale Food Producers in Serbia: the Use of Facebook in the Market in Sociološki pregled, 55(4): 1311-1337. doi: 10.5937/socpreg55-34272
[35]Vlasova, A., 2019, Digitalization of agriculture. In: Digital Agriculture-Development Strategy, Proceedings of International Scientific and Practical Conference (ISPC 2019), 21-22 March 2019, Ekaterinburg, Russia; Atlantis Press: Paris, France, 405–409. http://creativecommons.org/licenses/by-nc/4.0/