DIGITALIZATION FOR AGRICULTURE AND RURAL DEVELOPMENT IN UKRAINE

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Abstract. The introduction of digital technologies in agricultural production is one of the most important elements of strategic development in the agricultural sector and rural areas in Ukraine. In agriculture, these new technologies can modernize the industry, promoting innovation in agribusiness and creating new opportunities for rural development. The introduction of digital technologies in agriculture ensures the accuracy of measurements, speed data collection and processing. Digitization in rural areas is an inevitable process that brings a number of economic, social and environmental benefits. The immediate aim of this paper is to assess the state of implementation of digital technologies in agriculture and to examine opportunities for rural development in Ukraine. Research methods: monographic, descriptive, analysis, synthesis, induction. The results indicate that only large agricultural enterprises in Ukraine are able to implement and use digital technologies. Thus, it is proposed to create an integrated digital portal for agricultural needs, combining solutions that optimize activities of agricultural enterprises: land bank management, production, crop monitoring, warehouse, procurement and supply, equipment and repairs, logistics, inventory and finished products. The article identifies technological and human barriers to introduction of digital technologies in rural areas of Ukraine. In addition it proposes strategies for development of digital literacy and skills among rural residents in Ukraine. The results of the research can have a significant impact on the development of agriculture in Ukraine, promoting digital technologies among other agricultural enterprises and ensuring the development in rural areas, attracting additional agricultural market participants and infrastructure that provide relevant information and digital services to rural residents.

Keywords: agriculture, rural development, digital technologies, integrated digital portal, rural areas.

JEL code: O18, Q16

Introduction

Agrarian business is a type of activity that is based on a huge amount of data. To ensure competitiveness on the market, it is necessary to increase the efficiency of land use, equipment and inventory, goods and materials values. Moreover, this is impossible without planning, control and accounting of the entire chain of production processes. For a long time, agricultural enterprises in Ukraine were engaged only in expanding the land bank, which was not accompanied by improvements in technology or optimization of farm management. The latter led to the emergence of unique conditions. In Ukraine there were agricultural enterprises with significant land banks, which kept records of plots and fields on paper maps, did not plan production programs, kept inventory on files, had virtually no control over the cost of fixed resources, post factum cost analysis products and key performance indicators.

Agricultural enterprises in Ukraine have previously tried to simplify the work of departments and services. However, these were the simplest solutions – for example, Excel spreadsheets. More advanced companies used 1C for the accounting department, telemetry modules for dispatching services and control of equipment use. Small and medium-sized agricultural enterprises tended to stop at this stage. Large agricultural holdings needed to digitalize business processes, automate planning and management processes. They continued to integrate IT technologies in all spheres of activity of the enterprise. Different departments of one enterprise could use different external solutions. This has led to problems with limited narrow-minded functionality, data reception, solution integration, and operational management reporting. This situation led to delays in work, decision-making and, as a consequence, additional financial costs.

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Therefore, there is a need to integrate the business processes of agricultural enterprises in Ukraine as a whole and to create an appropriate information system that would interact with different operational processes and allow optimizing economic activity.

In turn, the need for digitalization was felt in the rural areas in Ukraine, since the agricultural enterprises that operated in these areas needed appropriate changes, as well as staff and rural gadget owning residents were seeking information and services. However, there are some obstacles to the introduction of information technology, such as - lack of Internet access or limited mobile coverage in rural areas. While the vast majority of rural residents (elderly population) do not need such changes, the young and middle-aged people remaining in rural areas are engaged in entrepreneurial activities, have their own homestead, farm or work in medium or large agricultural enterprises. Accordingly, there is a strong need to develop appropriate strategies to ensure rural development in Ukraine through digitalization.

The research aims to assess the state of digital technologies' implementation in agriculture and opportunities for rural development in Ukraine.

Specific research tasks were set to achieve the aim: 1) to identify the main stages of digitalization and explore the elements of digital system Farming 4.0 in agriculture; 2) to propose the integrated digital portal for agriculture; 3) to examine barriers and problems of digitalization in rural areas and to develop proposals for further development of rural areas in Ukraine.

The research developed conclusions and recommendations for further development of rural areas and introduction of digitalization in agriculture in Ukraine.

Research results and discussion

1. Digitalization for agriculture in Ukraine

Today the most important transformation of activities in the agricultural sector in Ukraine is digitalization. This phenomenon is designed to simplify activities in the agricultural sector in Ukraine, agricultural production and make it more efficient, in order to ensure rural development. It offers an opportunity to transform a huge amount of information into a structured data system and facilitate the activities of agricultural enterprises, which differ in their industry specifics and requirements for the management system. Digitalization in agriculture radically changes the approach to organization of collection, processing, storage and use of the data, reducing production costs, increasing productivity, and hence profitability.

There are two main areas in which digitalization is moving, namely productivity and the creation of fully digital enterprises in the future. The use of new technologies in agriculture reduces overall costs, thereby increasing profits. It is through digitization that agricultural enterprises are realizing that they can improve in their field. Thus, less effort is needed, as digitalisation helps to overcome barriers and to make it easier to move to a new management level of agricultural enterprise. With the digitization of data, the methods of agricultural production are also undergoing significant changes. At this stage, many agricultural enterprises in Ukraine have the chance to become leaders with minimal costs, only through the digitalization of production, and the rural areas in which they operate to provide socio-economic development. The second direction of digitalization is "digital enterprises". They are indebted for their creation to cloud technologies and exist on the basis of remote work.

We have identified the main stages of digitalization (Figure 1). With the development of new technologies, each agricultural enterprise in Ukraine is on the path to gradual digitalization of its own activities. It all starts with the spontaneous digitization of information (first stage), which gradually leads

to the formation of a large array of information in the form of BigData. At the second stage, agricultural enterprises can receive a large amount of information, both internal information (statistical and accounting reports of structural departments in the crop or livestock complex, reports on the production and sale of agricultural products, information from the financial department etc.), and external information (the results of marketing research, forecasts based on the results of crop yields, price proposals etc.). In order not to process a significant amount of information, each employee of an agricultural enterprise or of a relevant structural department can access this unsystematized BigData and find the data needed for analysis, grouping, usage, and storage. In this case, a significant amount of working time is not spent and the costs of its processing are optimized. At most agricultural enterprises in Ukraine, this information is accumulated in spreadsheet processors or accounting programs. Only by moving to the third stage of the BigData grouping, agricultural enterprises in Ukraine have a chance to catch up with the latest global trends in technology. The complete digital transformation of agribusiness (fourth stage) is a goal that every agricultural enterprise should strive for. Doing business exclusively in digital format will allow agricultural enterprises to no longer depend on printed methods of information storing, conduct all business negotiations online and perform any tasks without being tied to the office. The transition to the last stage of digitalization will greatly simplify life and reduce costs, but it can not be achieved without gradual work on data conversion.

first stage	Digitization of data
second stage	Not systematized Big Data
third stage	Grouping Big Data
fourth stage	Digital transformation

Source: authors' construction

Fig. 1. **The main stages of digitalization**

The problem of most agricultural enterprises in Ukraine is that, due to conservative views, they are delayed for a very long time at the first stage. While companies around the world have begun to digitalize long time ago, domestic producers are literally stuck in the past. However, there are cases of positive use of digital technologies, such as in large agricultural holdings - Kernel and Astarta-Kyiv. The abovementioned agricultural enterprises in Ukraine have their own information and digital systems that are adapted to Farming 4.0. This digital system combines several elements (Table 1). Farming 4.0 involves the mass introduction of cyberphysical systems in production (Industry 4.0), serving all human needs, such as labor and leisure.

Table 1

Farming 4.0 for agriculture

Elements	Characteristic
Production (produce more with less)	Improvements in technology through quality seeds, diversified application of complex fertilizers, technical re-equipment and other innovations. Ukraine will increase grain production, primarily by increasing corn yields. Growth is also expected in the production of oilseeds due to soybeans in particular and legumes in general.
Technologies	Computerization and digitalization affect all areas of agrarian activity. From the transfer of all accounting to paperless forms and the rejection of cash and ending with the complete robotization of dairy farms or unmanned management of the entire fleet of agricultural machinery. The main challenge will be working with a huge array of data. One of the central issues is cybersecurity.
People	The number of people working in agriculture in Ukraine has halved over the past 15 years. However, labor productivity in the agricultural sector is extremely low. So, in agricultural holdings, there are 15-25 workers per 1 thousand hectares, for farmers – 10-15. The number of people employed in rural areas in crop production in a few years will reach the level of two workers per 1 thousand hectares. In animal husbandry, the situation will not differ much from crop production due to the complete robotization of the main production processes.
Rural areas	Urbanization will continue to increase the outflow of young people from the countryside. The traditional Ukrainian village in most regions can be saved from complete extinction only through the presence of adequate local authorities and the creation of tax offshores in rural areas for agricultural business.
Education and science	Since no more than 100 thousand people will be employed in the agricultural sector in the future, it is obvious that the current number of students in agricultural institutions – 130 thousand – is excessive. 2.5-3 thousand graduates, including vocational education, every year is the indicator that will be in demand in the agricultural sector. At the same time, the trend here is already clear: the creation of multidisciplinary centers in conjunction with mathematicians, geographers and other specialists. Most likely, there will be no purely agricultural universities; they will turn into multidisciplinary faculties at classical universities. Applied science will move into business structures. Fundamental sciences will be studied at universities.

Source: authors' construction based on Arıcıoglu et al., 2020; Liu et al., 2021; Ozdogan et al., 2017

One of the effective tools of digitalization for agriculture in Ukraine is integrated digital portal for agribusiness management (Table 2). It consists of 8 modules, each of which fully covers the needs of a separate unit of the production chain. It is possible to use one module separately, combine them depending on the needs or combine with third-party services.

Table 2

Integrated digital portal for agriculture in Ukraine

Module	Characteristic
AgriChainLand	Module for online land bank management, it covers databases of all fields and plots of the enterprise, management of land exchanges, leases, payments and accruals, including cost budgeting. The functionality of the land module helps to avoid common risks associated with land management, such as inaccurate or untimely information, differences in the area of leased and cultivated land, violation of procedural actions under land lease agreements and many others.
AgriChainFarm	Module for planning, executing and production program management with automated document management related to the display of business transactions. The main tasks of the system are seasonal planning of the production program, construction and automation of business processes for operational management of the operating cycle on the basis of a seasonal plan between all departments: agronomic, engineering, control, warehousing, economic and accounting in real time.
AgriChainScout	Module for online monitoring of crops, their analysis and dynamic forecasting of yields. The main tasks of the system are to build the culture and business processes for systematic monitoring of crops for effective risk control and making the right management decisions. The system allows you to collect information about the state of crops from different sources (historical, satellite, aerial photographs), automatically schedule field surveys, plan individual rules of inspections in relation to culture, timely identify risks – diseases, pests, weeds to make decisions on their prompt elimination and evaluation of their economic efficiency, receive operational business analytics and reports on the state of crops.
AgriChainBarn	Module for online management of warehouse logistics of the enterprise with automated document management. The main objectives of this module are to build efficient warehousing logistics using additional equipment (data collection terminals, barcode printers, scanners), which will allow to build business processes for effective traffic management of goods and materials values, traffic control and packaging disposal, thus optimizing logistics' costs and warehouse balances.
AgriChainKit	Module for business processes management of the agricultural enterprise. This solution is integrated with other modules of the platform, while setting up business processes is implemented as a flexible designer (to meet the demand and features of any agricultural enterprise), which in case of changes in external and internal business conditions allows to quickly adjust the enterprise, creating the most complex schemes of business processes at the user level, personalize areas of responsibility, gather management tasks of specialists, control the timing of their implementation.
AgriChainLogistics	Module for logistics management of goods and materials values (warehouse-field) and products from the field (field-threshing floor-elevator / sugar factory) with automated document management (universal consignment note), is a workplace for logistics management of own and hired equipment.
AgriChainAuto	Module for work control and equipment repairs (own system of GPS-monitoring).
AgriChainReport	Module for generating analytical reports using the Business Intelligence system as part of the AgriChain portal.

Source: authors' construction based on Fountas et al., 2020; Lopez-Morales et al., 2020; Qin et al., 2022; Xiong et al., 2020

Integrated digital portal for agriculture in Ukraine ensures the efficiency of agricultural production through completeness, objectivity of data and the ability to work with them. The use of digital portals provides agricultural enterprises with optimization of operational processes. Digital portal modules are integrated with each other and have management functions. The concept AgriChain solution is based on full integration with the 1C accounting system, GPS-monitoring system, satellite and meteorological data, which complement the system with necessary indicators, simplify paperwork and process complexity.

Moreover, if the data available to the agricultural enterprise is organized, structured and stored electronically, then the deployment of the system can be performed in the shortest period.

2. Digitalization for rural development in Ukraine

Agroholdings in Ukraine, which operate in rural areas are concerned about the quality of labor organization based on the latest technologies that can remotely measure soil condition, improve water management, track yields and all production processes using telephones, tablets, field sensors, quadcopters and drones. However, rural residents continue to live on land and prefer to work as their ancestors used to in the previous and even the last century, avoiding new trends.
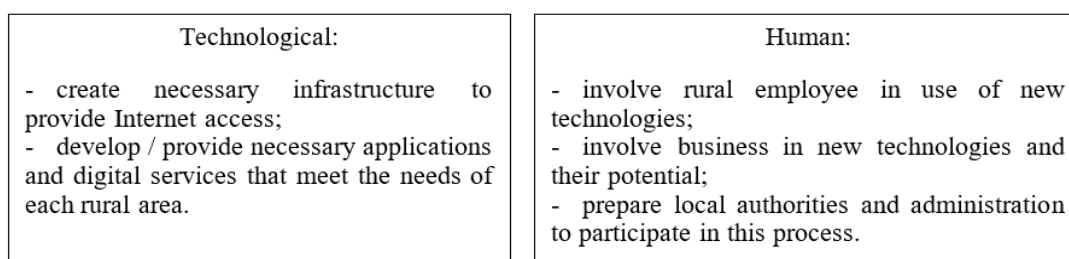
Can rural areas develop through the fourth technological revolution? To what extent are the villagers aware of this aspect?

To understand global trends in digital adoption by the average rural resident, let's start with the technological phenomenon we have become accustomed to – broadband Internet, which, according to the UN, belongs to the third industrial revolution. In the West, the digital potential of rural areas has not been fully revealed. Meanwhile, according to a study (Wilson et al., 2018) of the British companies Rural England CIC and Scotland's Rural College (SRUC), conducted with the support of Amazon, its full use across the UK could add to the country's economy from 12 to 26 billion pounds of gross value added per year. Moreover, most of this productivity growth (over 9 billion pounds) will come from micro-enterprises – home or family farms that employ up to nine people.

Currently, more than 50% of Ukrainian villages are not connected to broadband Internet channels at all. As a result, a large number of citizens are virtually deprived of the opportunity to participate in modern forms of communication and apply the latest technologies in farming. Of course, this is a state-level issue. However, if private agricultural enterprises do not lobby for the active "internetization" of rural areas, the only thing left to do is to cover the digital gap in coming years and decades.

Partnerships need to be sought to accelerate the arrival of digital innovation for rural development in Ukraine. The main strategy is to negotiate and unite, to find compromises and common points of entry for all stakeholders. These can be local communities and authorities, as well as foundations, enterprises, educational institutions, recruitment companies, etc.

In the struggle for widespread digitalisation for rural development in Ukraine, it is important to take into account common barriers and the scope of possible impact on them. This requires a comprehensive approach to digital change in the agricultural sector in Ukraine. Thus, we proceed from the fact that for rural development in Ukraine it is necessary to realize the two main barriers to digitalization (Figure 2).

Technological:	Human:
- create necessary infrastructure to provide Internet access; - develop / provide necessary applications and digital services that meet the needs of each rural area.	- involve rural employee in use of new technologies; - involve business in new technologies and their potential; - prepare local authorities and administration to participate in this process.

Source: authors' construction

Fig. 2. **Two main barriers to digitalization for rural development in Ukraine**

In order to eliminate barriers to digitalization for rural development in Ukraine, several methods seem to be the most effective in current reality. By analyzing the facts listed below and tracking new relevant

solutions, you can create your own strategies for dealing with difficulties and challenges, based on available opportunities and resources. To do this, we propose to use several rural development strategies in Ukraine.

Fact 1 – in rural areas, the potential of information and communication technology users is quite limited, and agricultural enterprises need qualified personnel to work. Therefore, every manager often has a natural desire to replace staff.

Strategy – take course to building a digitally woke team:

- search for potential employees with relevant skills;
- determination of hiring and maintenance methods and conditions;
- recognition of growing talents among the already hired employees;
- telemetry, real time monitoring of the digital skills typical for existing professions and positions.

Fact 2 – in rural areas, there are not enough specialists to disseminate information in the right formats. For example, a retired-shareholder does not understand why he uses a digital technology company because he is used to reading newspapers. However, a 25-year-old tractor-driver responds to the messenger. In addition, rural residents are almost unaware of the possibilities of new digital applications available to them individually and to agribusiness in which they are involved. Therefore, the acquisition of digital skills and competencies not a priority but an inner desire.

Strategy – carefully prepare all communications. First, adapt and test digital news on the most loyal people in rural areas to check correct perception of information. In addition, anticipate possible questions and work with objections in the future.

Benchmark – ET Alibaba's agricultural brain, artificial intelligence program, assesses the pig's health by its appearance, temperature and voice. The technology determines a cow's pregnancy by external indicators of behavior: how it stands, sleeps and eats, and in addition, the program can warn piglets of possible accidents. According to the Chinese Ministry of Statistics, using the Alibaba program on all pig farms in China will save 7.5 billion dollars USA (Werkheiser, 2020).

Fact 3 – the limited range of e-services in the public sector on the level of health care, education, tourism, etc. leads to a lower need of rural residents to use commercial technologies / software. Moreover, the low level of entrepreneurship in rural areas hinders development of digital skills.

Strategy – to develop cooperation with subsidy structures and funds based on successful European examples of creating rural digital hubs that can inspire development of Ukrainian analogues.

Benchmark – Rural Hub Cocotte Numerique (France), founded in 2005, was originally established as a public service center to promote the work of farms and the attractiveness of this type of activity. It has a multimedia room, Internet access, digital education and training. During 10 years of active work, the French rural digital hub has expanded its arsenal. For example, it has created a website that attracts workers to this region of the country. This uses the "welcome" strategy to help new residents and their families to settle in the area. The center also organized distance learning / coaching for "independent digital workers" and young people (Price et al., 2022).

Fact 4 – lack of educational structures that would enable the rural population to develop skills and competencies focused on their specific needs.

Strategy – to carry out smart digital learning and skills development on a regular basis. As this is a costly affair, we recommend, in addition to internal corporate opportunities, to cooperate and create models for interaction with other stakeholders. These could be, for instance, industry and expert councils, coalitions, working groups. Such proactive associations may be responsible for following areas:

- - analysis of progress and needs of specific digital policies and programs in the region;
- - monitoring of new technological developments;
- - accounting and forecasting the needs of the workforce that uses digital culture in business processes;
- - assessment of new opportunities for learning digital skills;
- - identification of new partners;
- - joining new regional or global digital campaigns;
- - development of new initiatives.

The proposed strategies for rural development in Ukraine will ensure the formation of competencies and practical skills of the population in use of digital technologies and promote implementation in agricultural enterprises, which will optimize production costs, better use of resource potential, ensure productivity and efficiency of agricultural processes, increase income and profits of agricultural enterprises. For rural areas, this will improve the economic condition of communities, attract more agricultural enterprises and entities of market infrastructure, increase level education and dissemination of modern information technologies among the population, not only specific (for agricultural production), but also relevant to today's conditions (educational, administrative, medical, social etc.). In the future, this will be an additional incentive for young people employed in rural development in Ukraine and conduct not only agriculture but also entrepreneurship.

Conclusions, proposals, recommendations

1) Ensuring agriculture development in Ukraine is achieved through the introduction of digitalization in the direction of increasing productivity of production (optimization of costs and increased profits and profitability) and digitalization of agricultural enterprises (introduction of current digital technologies).

2) Currently, agricultural enterprises (primarily agricultural holdings) in Ukraine within the digitalization are at the level of the grouping BigData. Restraint of the digitalization process is due to the complexity of introducing digital technology, unpreparedness or lack of personnel capable of perceiving changes, dependence on third-party structures that provide a comprehensive solution to production processes (outsourcing – logistics, elevators, exports etc.). Large agricultural enterprises in Ukraine, which seek further development, are actively trying to follow the concept of Farming 4.0 and improve business processes in accordance with the best world practices of agricultural production and implement digital technologies.

3) We propose the formation of an integrated digital agribusiness management portal, which would allow enterprises to combine, optimize and interconnect with production, logistics, economic processes, opening new opportunities and qualitatively transforming the nature of interaction, social integration and communication in general. The introduction of such information systems in agriculture in Ukraine encourages enterprises to use land efficiently, monitoring the quality of agricultural machinery, ensure the quality of agricultural activities and their automation, transparency and controllability of production processes, reduce costs, and get positive economic effect from digitalization.

4) Agriculture development in Ukraine directly depends on ensuring the well-being of rural residents and the development of territorial communities. Research shows that there are problems with the introduction of digital technologies in rural areas (lack of Internet access), the use of traditional methods of agricultural production and unwillingness to make progressive changes. Additionally, there have been identified technical and human barriers to the introduction of digitalization.

5) In order to ensure rural development in Ukraine, the main problems have been studied and appropriate strategies have been proposed. The main strategies include: (a) developing the digital skills among the rural population; (b) adaptation and monitoring of digital skills of rural residents; (c) development and cooperation with contractors of electronic services for distribution among the rural residents; (d) implementation of training and development of digital skills among the rural residents.

6) Prospects for further research of digitalization for agriculture in Ukraine are the use of artificial intelligence and modeling elements. For example, the system itself develops planned crop rotation, taking into account the predecessors that were on the fields, taking into account the set of arrays, geography, logistics, set by the agricultural enterprise. The best, average and bad predecessor – all this embedded in a certain model. An example of algorithms is the structure of elevator logistics, how many shafts there are, how many need to be taken to one elevator, how much to keep on the other, how much to leave on the threshing floor. The system takes into account the algorithms of the optimal route, the minimum distances of removal from the field, and suggests the fields from and to which removal will take place.

7) Prospects for further rural development in Ukraine are the rapid and effective use of new digital technologies through strategic partnerships with agricultural holdings, agricultural innovative hubs, educational institutions, support services for the implementation of educational programs, acquisition of theoretical and practical digital skills, dissemination of modern software in order to support rural residents and the provision of appropriate remote information services.

Bibliography

1. Arıcıoglu, M., Yılmaz, A., Gulnar, N. (2020). 4.0 For Agriculture. *European Journal of Business and Management Research*, 5(3). Retrieved: https://doi.org/10.24018/ejbmr.2020.5.3.364. Access: 04.04.2022.
2. Fountas, S., Espejo-Garcia, B., Kasimati, A., Mylonas, N., Darra, N. (2020). The Future of Digital Agriculture: Technologies and Opportunities. *IT Professional*, Vol. 22, No. 1, pp. 24-28. Retrieved: https://doi.org/10.1109/MITP.2019.2963412. Access: 05.04.2022.
3. Liu, Y., Ma, X., Shu, L., Hancke, G., Abu-Mahfouz, A. (2021). From Industry 4.0 to Agriculture 4.0: Current Status, Enabling Technologies, and Research Challenges. *IEEE Transactions on Industrial Informatics*, Vol. 17, No. 6, pp. 4322-4334. Retrieved: https://doi.org/10.1109/TII.2020.3003910. Access: 05.04.2022.
4. Lopez-Morales, J., Martinez, J., Skarmeta, A. (2020). Digital Transformation of Agriculture through the Use of an Interoperable Platform. *Sensors*, 20(4), 1153. Retrieved: https://doi.org/10.3390/s20041153. Access: 04.04.2022.
5. Ozdogan, B., Gacar, A., Aktas, H. (2017). Digital Agriculture Practices in the Context of Agriculture 4.0. *Journal of Economics, Finance and Accounting*, Vol. 4, Issue 2, pp. 184-191. Retrieved: http://doi.org/10.17261/Pressacademia.2017.448. Access: 04.04.2022.
6. Price, L, Deville, J, Ashmore, F. (2022). A Guide to Developing a Rural Digital Hub. *Local Economy*. Retrieved: https://doi.org/10.1177/02690942221077575. Access: 04.04.2022.
7. Qin, T., Wang, L., Zhou, Y., Guo, L., Jiang, G., Zhang, L. (2022). Digital Technology-and-Services-Driven Sustainable Transformation of Agriculture: Cases of China and the EU. *Agriculture*, 12:297. Retrieved: https://doi.org/10.3390/agriculture12020297. Access: 05.04.2022.
8. Werkheiser, I. (2020). Technology and Responsibility: a Discussion of Underexamined Risks and Concerns in Precision Livestock Farming. *Animal Frontiers*, Vol. 10(1), pp. 51–57. Retrieved: https://doi.org/10.1093/af/vfz056. Access: 05.04.2022.
9. Wilson, B., Atterton, J., Hart, J., Spencer, M., Thomson, S. (2018). *Unlocking the Digital Potential of Rural Areas across the UK*. Amazon commissioned research report by Rural England and SRUC, 94 p. Retrieved: https://ruralengland.org/wp-content/uploads/2018/03/Unlocking-digital-potential-website-version-final.pdf. Access: 04.04.2022.
10. Xiong, H., Dalhaus, T., Wang, P., Huang, J. (2020). Blockchain Technology for Agriculture: Applications and Rationale. *Frontiers in Blockchain*, 3:7. Retrieved: https://doi.org/10.3389/fbloc.2020.00007. Access: 05.04.2022.