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DIGITALIZATION IN AGRICULTURE: PROBLEMS OF IMPLEMENTATION

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The relevance of the research topic is determined by the fact that at the present stage the targets of modern agricultural production are concluded in the need to increase the volume of output of livestock and crop production while maintaining quality. At the same time, this topic has a certain problem field, since the growth rate of output in the industry in question is impossible today without the use of advanced technologies. In this context, the leading role belongs to the digitalization of agriculture, since only through high-tech approaches at the present stage it is possible to ensure highly competitive work of agricultural enterprises.

The purpose of the study is to analyze the problems of digitalization implementation in agriculture. In the process of writing the work, comparative, analytical methods were used, through which a number of publications and monographs of recent years were studied within the framework of the topic of this article.

The results of the study should include the justification of the need to implement a number of measures including retraining and training of personnel, synchronization of existing production processes with innovative solutions, as well as to organize the necessary financing for the implementation of these measures. It was concluded that these measures will optimize the process of digitalization of the agricultural sector and increase the productivity of agricultural enterprises.

Keywords: *digitalization; agriculture; personnel training; innovative solutions*

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ЦИФРОВИЗАЦИЯ В СЕЛЬСКОМ ХОЗЯЙСТВЕ: ПРОБЛЕМЫ ВНЕДРЕНИЯ

Е.Ф. Амирова, Н.К. Гаврильева, А.В. Григорьев, И.В. Соргутов

Актуальность темы исследования определена тем, что целевые ориентиры современного сельскохозяйственного производства заключены на со-

временном этапе в необходимости повышения объема выпуска продукции животноводства и растениеводства при сохранении качества. При этом, указанная тема имеет определенное проблемное поле, поскольку темпы прироста объемов выпуска продукции в рассматриваемой отрасли невозможны сегодня без применения передовых технологий. В данном разрезе ведущая роль принадлежит цифровизации сельского хозяйства, поскольку только за счет высокотехнологичных подходов на современном этапе можно обеспечить высоко конкурентоспособную работу предприятий АПК.

Целью исследования выступает анализ проблем внедрения цифровизации в сельском хозяйстве. В процессе написания работы были применены сравнительный, аналитический методы, посредством которых было проведено исследование ряда публикаций и монографий последних лет в рамках темы настоящей статьи.

К результатам исследования следует отнести обоснование необходимости осуществления ряда мероприятий включающих переподготовку и обучение персонала, синхронизацию существующих производственных процессов с инновационными решениями, а также организовать необходимое финансирование внедрения указанных мероприятий. Был сделан вывод, что указанные мероприятия позволят оптимизировать процесс цифровизации сельскохозяйственной отрасли и повысить производительность труда предприятий сферы АПК.

Ключевые слова: *цифровизация; сельское хозяйство; подготовка персонала; инновационные решения*

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Introduction

Agriculture is one of the main industries that affect the level of employment of the population and the economy of any country as a whole. The introduction of digitalization in the agricultural sector is just beginning, the pace of implementation is very low, which significantly slows down the process of increasing the pace of production and the entire business chain of food production and sale. The adoption and implementation of digitalization of agriculture can improve life and accelerate the development of the economy [4].

Digital agriculture is defined as the design, development, conceptualization, application and evaluation of innovative ways of applying new information

and communication technologies [5]. Agriculture is, as you know, one of the most important sectors of the economy, for this reason, information technology should gradually replace the old techniques and methods of work, allowing to increase the productivity of agricultural enterprises several times [1].

The purpose of the work is to consider the features of digitalization in agriculture and identify the problems of its implementation in the production and management process of this sphere.

Materials and methods

In the process of writing the work, comparative, analytical methods were used, through which a number of publications and monographs of recent years were studied within the framework of the topic of this article.

Results

The ever-growing global demand for food, feed, fiber and clean energy increases the pressure on agroecosystems. Increased stress negatively affects the natural sustainability of agroecosystems and is expected to lead to unprecedented environmental changes on a global scale [12]. Changing climatic conditions are accompanied by high and low heat stress, changes in precipitation patterns, increased carbon dioxide content, increased frequency of extreme weather events such as droughts, floods, cyclonic disturbances and increased soil salinization. These effects lead to an increase in production costs, pest infestation, and morbidity, which together increases the burden on agricultural land worldwide [17].

Due to the growing demand for food, supply chain tensions and declining soil carbon levels pose a challenge for future generations to meet the nutritional needs of 9.7 billion people by 2050.

The emergence of digital technologies in agriculture can contribute to reducing the tension of this situation. Digital technologies are expanding the scale of sustainable management of agricultural lands and resources, as well as increasing the associated productivity, services and security of livelihoods around the world [20].

Crop varieties, plots and sustainable farming methods for specific fields are being developed, and the data obtained as a result of promising practices can be stored and analyzed using digital technologies. Digitalization has advanced rapidly in the agricultural sector, making its presence felt in various aspects, such as land assessment, soil and crop suitability, weather information, crop growth, biomass and productivity, precision farming, as well as various stages of agricultural production. the chain (processing, packaging, delivery, consumption and handling of agricultural waste) [8].

Digitalization adds multi-purpose benefits to global agriculture through real-time monitoring, conventional smartphones and fingertip-based computers, as well as consultations based on satellite and meteorological information. These IoT technologies can prevent and allow you to plan solutions to upcoming problems, such as pest infestations or disease outbreaks.

Digital technologies also help to choose optimal methods focused on high yields, accurate resource costs, lower production costs with higher nutritional quality of agricultural products, geotagging for accurate prophecy, energetic and flexible farming methods, crop data management, post-harvest services, and agroindustries. Various technologies such as remote sensing, geographic information System (GIS), smartphone, robotics, artificial intelligence, genomics, bioinformatics and digital technologies based on big data are used to achieve the goal of agricultural sustainability and the goals of the UN SDGs [12].

In the conditions of digitalization, various equipment is used (sensors, ground robot, drones, automation of nurseries, robotics, robotic irrigation, precise fertilization of the soil between dense crops, automated tractors for harvesting), software (geocarting, computer visualization technology), and their combination (robots for micro-spraying for targeted use of herbicides, automated weed uprooting and robotics for pruning with computer visualization) are already in use [10]. The details and implications of using the Internet of agricultural technologies are described in the following subsections, which define the promising opportunities offered by digitalization.

Attention should be paid to individual technologies in the framework of digitalization of agriculture. Remote sensing (RS) and GIS methods offer various solutions, ranging from the identification of crop species, sustainable management of farming systems by an individual agricultural enterprise to the development of agricultural policy. Thus, increased agricultural production, conservation of resources, aboveground biodiversity, gender equality and empowerment of farmers can be achieved by integrating these modern digital tools [14].

The integration of RS-GIS, fuzzy logic and multi-criteria assessment using the analytical hierarchy process allows you to create an excellent database and a guide map for effective land use models, crop diversity, planning, monitoring of agroecosystem activities and decision-making. These integration methods provide fast and efficient access to a large amount of information, identifying relationships, patterns and useful trends for combining soil research data in order to more accurately assess the suitability of land use. Studies have demonstrated the advantages of using these methods as a viable alternative to high-performance and stable agricultural systems over time [17].

Intelligent integration of GIS-based technologies promises better farming systems in production areas with increased resilience while mitigating the effects of climate change. For example, GIS remote sensing tools have been used in citrus orchards in China, where digital maps and simulation-based knowledge of terrain topography, land use, soil types, climatic conditions and altitude predicted suitable areas for citrus cultivation and their sustainable development. management from the field to the end users.

The RS data help in exceptional cases to decipher the spatial and temporal characteristics of the earth, including the influence of the environment on the growth of crops. So, there is evidence that these technologies have been applied to increase the sustainability of potato production.

The use of extended multispectral images in the RS was emphasized as an effective monitoring tool for determining vegetation dynamics, plant health and crop yield prediction with various methods of work. Consequently, decisions related to the quantitative export and import of the product within the region can be made with confidence in order to increase the net economic benefit for the agricultural sector [16].

Through RS-GIS-based technologies, operators of agricultural enterprises receive accurate maps, crop information, field assessment and soil characteristics that are beneficial to state producers, since they can provide the necessary projects to support farmers. In addition, these systems provide more accurate information about climatic parameters for the creation of heat- and drought-resistant crop varieties using various breeding approaches.

RS-GIS technologies are also used to reduce environmental pollution by agricultural waste. A significant number of plastic products made on the basis of synthetic polymers, which are used in agriculture in various processes, such as mulching, shading plants, annually becomes unusable. The sustainable management of land and crops, along with the maintenance of soil biodiversity, requires the regular removal of these polymers. Here it is possible to use easily updated databases and GIS-based maps that allow you to determine the volume of plastic on farms, outline places for plastic collection and develop a monitoring and decision-making system for identification and collection, followed by their proper delivery to farms. processing companies [10].

The involvement of geoinformatics and decision support systems in precision irrigation plays an important role in the sustainable management of water resources and is crucial for those countries where water is a scarce or very limited resource, as well as in arid and semi-arid areas. However, this method requires combining large sets of accurate and highly accurate data on the characteristics of land and water

resources. Factors such as the high cost of maintenance and calibration of sensors make its implementation tedious, especially in developing countries.

While these technologies are still a challenge for many countries, the availability of open source geospatial platforms such as GIS and RS opens up new opportunities for their application in low-income systems. In addition, the active participation of stakeholders is required to emphasize the availability and feasibility of such GIS software for the rest of the farming community and supply chain participants [14].

The world is now experiencing an era when online information is becoming more widespread, and various applications for phones, computers and other devices are used to obtain it. A scientific approach to the process of digitalization in the agricultural sector can further stimulate the integration of new digital technologies into agricultural practice, offering several opportunities to significantly improve the social, economic and environmental sustainability of food production systems.

Discussion. Globally, agricultural transformation is proceeding at a rapid pace, with information and communication technologies (ICT) and digitization being central participants in this process. The use of mobile application software by almost all stakeholders in agriculture increases the efficiency of resource use and equally helps to reduce the costs associated with production, while increasing productivity and net economic profit [16].

The use of mobile applications by professionals in the field of agriculture, science and technology provides access to information related to farming methods taking into account climatic requirements. The integration of digital access helps to make decisions during production and at subsequent stages of the supply chain. Today, more than 5.2 billion people in the world have access to mobile devices worldwide. Worldwide, the number of cell phone users exceeds 3 billion, and in the next few years their number will grow by several hundred million. The effectiveness of mobile phones and applications was also confirmed, as well as their importance for the dissemination of agricultural information among agricultural specialists.. However, the use of ICT in agriculture does not always lead to an increase in harvests and profits for each farm [19].

Thus, despite the positive results of using mobile applications in improving small-scale agriculture, many farmers still remain in the “dark” due to lack of access to technology. It is noteworthy that vital obstacles that hinder digitalization in agriculture (for example, the use of mobile phones/applications and ICT), especially in rural areas, include lack of Internet connectivity, lack of digital capabilities, difficulties with using ICT applications, as well as digital illiteracy[12].

Climate change threatens the growth of agricultural production, food security and the livelihoods of millions of people around the world. Agriculture

contributes significantly to greenhouse gas (GHG) emissions and global warming. Climate-optimal agriculture practices based on digital technologies that combine the benefits of sustainable production, climate change resilience and greenhouse gas emissions reduction seem very promising and offer a potential solution to existing problems [10]. However, despite the various advantages of optimal agriculture technologies, currently the level of their adoption by farmers is relatively low. Factors such as the socio-economic characteristics of farmers, the biophysical environment in a particular location, and the characteristics of new technologies influence the adoption of optimal agriculture technologies. Food systems must undergo a significant digital transformation to address the ever-growing challenges of food security and climate change [7].

Digitalization also plays an important role in the organization of precision farming. Precision farming is the practice of farming carried out in a certain place and at a certain time, rather than uniform application throughout the field. Lower environmental risks, higher yields (reducing global hunger) and economic benefits (reducing poverty) for farming communities are fundamental attributes of precision farming. Precision agriculture uses robotics, artificial intelligence and deep learning processes for the next generation, and it is an environmentally sound practice of sustainable agriculture.

Modern unmanned aerial vehicles (UAVs) or drones capable of providing space-time and spectral recordings with hyperclass remote sensing can solve a variety of problems related to agroecosystems, the farming community and strengthen the path of precision farming. UAVs contain various sensors for predicting real-time information about drought, soil nutrients, plant growth, yield, diseases, pesticides and weeds, pests, weather parameters, soil type, moisture content, as well as spraying of pesticides and fertilizers [11].

Thermal imaging images, combined thermal and hyperspectral data, object-based images and UAV models can be the best technologies for detecting drought stress, determining crop yield opportunities and territories, etc.

Artificial intelligence has been proven to improve the impact of precision farming. For example, the integration of advanced artificial intelligence models, deep reinforcement learning, information and cloud technologies has the potential to conserve critical agricultural resources while increasing food production and sustainability. National governing bodies are also embracing the emergence of these integrated technologies to improve advisory services and data availability for agribusiness[16].

The Internet expands the system of knowledge about agriculture and the decision-making process for better management of agriculture. In addition, precision farming is growing faster thanks to the rapid research and development of

cheaper sensors, better control and computer imaging systems with developing artificial intelligence. Consequently, many semi-autonomous and autonomous unmanned ground vehicles or ground-based robotics have been successfully applied to seed sowing, irrigation, spraying, pruning, harvesting, real-time monitoring and mapping to save resources, finance and the environment.

In precision farming, data expressed in the form of various names, such as *Digital Farming*, *Agriculture 5.0* and *Smart Farming*, increase the accuracy of the agricultural enterprise and help in making critical operational decisions. For example, remote sensing technologies such as the American *Landsat* satellites, the European *Sentinel 2* satellite system, Indian remote sensing satellites (*IRS*), etc. This equipment provides agricultural information that helps in sustainable planning and management of agriculture [14].

Some other examples of robotic technologies, such as *Vinbot*, *VineRobot*, *VineScout* and *GRAPE*, have crop measurement devices and provide reliable multi-season monitoring of plant health.

In addition, there are also such interesting platforms in the field of robotics in agriculture as *Naïo Technologies* and *RowBot Systems* LLC. The first is associated with mechanical weeding, and the second is used for selective fertilization, mapping crop growth and other field-related tasks. The Geographic Information System (FIS) at the field level provides satisfactory information for implementation, operational planning and documentation for the management of farming systems.

Conclusion

The introduction of digital technologies in agriculture is a pointer to increasing incomes, improving nutrition and public health, optimizing food prices and creating jobs. It should be noted that the ability of agricultural companies to receive up-to-date information on the state of the environment or monitoring data on the main areas of agricultural activity, process and use it for the introduction of new technologies depends on the level of education and training of specialists in the agricultural sector, which is still at a fairly mediocre level. Accordingly, it is necessary to widely introduce new ways of training and retraining personnel of agricultural enterprises in the field of digitalization and informatization, as well as to train specialists of the agricultural sphere in specialized universities, taking into account the digital technologies being introduced.

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