Introduction of advanced information technologies in agriculture

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Abstract. The digital transformation of Russian agriculture is considered as one of the most promising areas for the development of domestic and global agricultural sector. The implementation of it will allow to overcome the existing global challenges arising from the growth of population and improvement of the quality of life, including: an increase in food demand (by 60% compared to 2050), increasing anthropogenic pressure on the environment (70% of water consumption and 30% of carbon dioxide emissions currently come from global agriculture), reduction of agricultural land and soil depletion. Also, the digitalization of agricultural enterprises will stabilize the situation in agricultural markets through the production and marketing of agricultural products that meet consumer preferences, formed in the process of development of a model of conscious and environmentally friendly consumption.

1 Introduction

Modern digital technologies are rapidly spreading, actively integrating into various fields of activity. Innovative tools make it possible to solve problems that are relevant to modern society quickly, which becomes even more necessary in conditions that directly push a person to the intensive use of digital technologies and artificial intelligence [1, 16, 17].

2 Problem statement

Digitalization is one of the most important factors determining the goals and vectors of the currently observed transformation of business processes in such significant economic sectors

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as industry and agriculture. The introduction of digital tools in the agri-food system allows to remove all sorts of barriers that hinder the increase in labor productivity, thereby increasing the competitive advantages of the enterprise. In addition, the integration of innovative technologies improves the system of interaction between agricultural producers, suppliers, contractors and other participants in the commodity distribution chain that can satisfy the need of the agro-industrial complex (AIC) in high-quality seeds and fertilizers. Accordingly, for agriculture, digitalization is becoming one of the key areas for the development of the agro-food system, the main task of which is to ensure food security and improve the market position of agricultural enterprises, especially in those areas where they are the main source of livelihood [1, 14, 15]. An important element of this process is the integration of digital technologies into public administration in the field of agriculture. It contributes to the development of communication channels between the agricultural business and authorized state structures [2].

3 Research questions

The purpose of research is to study modern information technologies in agriculture and give recommendations for improvement of products quality.

4 Materials and methods

This paper uses literary sources on the topic of use of advanced modern technologies in agriculture, information processing and introduces them into technological operations in order to improve the quality of products (grain, meat, milk, wool, etc.).

5 Results

In terms of agricultural land area, the Russian Federation ranks third in the world. It is behind the United States and India only. However, the pace of development of domestic agriculture is significantly behind the world average, which leads to a reduction in harvests, a drop in labor productivity and, as a result, an outflow of personnel from the agricultural sector: for example, according to 2017 data, employment in agriculture and forestry, hunting, and fishing and fish farming amounted to 4212 thousand people (5.8% of all employed in the economy). Gross added value of agricultural, forestry and fishery products for the same period amounted to 3694.7 billion rubles (4.44% of the total gross domestic product).

According to the results of the All-Russian Agricultural Census of 2016, the structure of the agro-food system of Russia has been formed. It includes: 36.1 thousand agricultural organizations, 7.6 thousand of them are large; 24.3 thousand are small; 4.2 thousand are medium agricultural enterprises and non-agricultural organizations; 174.8 thousand individual entrepreneurs and farm enterprises. An equally important place in the agro-industrial complex is occupied by personal subsidiary plots (PSP), the total number of which has reached 23.5 million, including 15.1 million PSP in rural settlements and 75.9 thousand agricultural associations (horticultural (67.3 thousand).), dacha (5.8 thousand) and garden (2.8 thousand)) [3].

The priority of the digital transformation of Russian agriculture is fixed at the federal level through the adoption of strategic planning documents approved by Decree of the President of Russia No. 204 dated May 7, 2018 “On the national goals and strategic objectives of the development of the Russian Federation for the period of up to 2024” [4].

The digitalization of agriculture is a complex process, the main goals of which are:

- improvement of the management system at the level of a particular farm, which is ensured by automating tools for prediction of the dynamics of changes in factors (natural-climatic, biological, soil, etc.) that determine the results of production;
- improvement of the management impact at the level of the agricultural sector by optimizing the management processes of economic entities dispersed throughout Russia;
- development of communication channels between agriculture, agribusiness enterprises, suppliers and contractors.

According to the Russian Ministry of Agriculture and experts, the use of digital technologies in the agro-industrial complex can reduce costs by at least 25%. The achievement of this goal is facilitated by the rationalization of the processes of distribution of incomes of the agro-industrial complex by investing them in the most promising areas of development.

However, the increase in the intensity of digitalization of the agricultural sector in the Russian Federation is significantly hampered by insufficient financial support for this industry. According to Rosstat, the cost of introducing information and communication technologies (ICT) in the agricultural sector in 2015 amounted to about 4 billion rubles (0.34% of all ICT investments), and in 2017 - 0.85 billion rubles (0. 2%). This suggests that the development and implementation of digital tools and technologies for the agricultural sector is featured by high investment potential [4].

6 Findings

The digital transformation of agriculture involves the introduction of innovative tools that ensure the rapid collection and processing of big data on the internal and external environment. To accomplish this task, it is advisable to use cloud platforms, solutions in the field of big data analysis and automated information systems [13]. It is also proposed to install specialized sensor equipment (field sensors, sensors for monitoring industrial premises and agricultural machinery, livestock health monitoring sensors, etc.) necessary for organizing a system of continuous three-level monitoring (ground, air and space) both at a separate agricultural enterprise and throughout the agro-industrial complex [1].

Improvement of the quality of big data processing, in its' turn, contributes to an increase in the efficiency of use of limited natural resources, which is a key principle of the ESG (Environmental, Social and Corporate Governance) strategy. Today, the introduction of such strategies is one of the most promising areas for the development of agriculture both in Russia and abroad.

The integration of digital technologies into agricultural processes provides extremely accurate forecasting of all kinds of changes in natural and climatic conditions, which is the basis of the system for monitoring the state of sown areas. In parallel, it is necessary to introduce innovative developments used to track the status of finished products, to supervise the activities of personnel, as well as to promptly implement state support measures.

The main barriers to the digitalization of Russian agriculture are given in Table. 1.

Table 1. Barriers to the digitalization of agriculture in Russia.

Barriers	Content	Solutions
The predominance of small farms in the structure of agricultural production	Inaccessibility of modern means of mechanization and automation, as well as fertilizers and chemicals for such farms. The result is low labor productivity, wages and high unit costs per unit of output; low level of enterprise resource management automation	Increasing the level of mechanization and automation to the global average becomes possible with the transition to the cloud automation consumption model; introduce elements of automated resource management and reduce the impact of the human factor at all stages of production and sale of agricultural products
Presence of agricultural giants	World practice has developed certain sizes of agricultural enterprises, the excess of which makes management impossible. Maintaining the parameters of technological processes and animal welfare standards. In this case, digitalization does not save and creates the illusion of controllability.	Formation of reference solutions for agricultural enterprises by size (land, plants and trees, animals, etc.) and standard solutions for information technologies and systems
Limited access to manufacturing technologies	There are few domestic manufacturers of high-quality production systems with built-in new technologies. Insufficient access to foreign systems and technologies	State support for manufacturers and consumers of modern agricultural machinery
Limited ability of Russian agricultural producers to buy modern equipment	There is no optimally equipped and staffed with qualified personnel dealer and service centers for the sale and maintenance of agricultural equipment, precision farming technologies are not sufficiently developed and implemented	The development and implementation of a contract model of the life cycle of equipment will significantly reduce the risks of agricultural producers, as well as significantly increase the availability of automation and mechanization of small farms
A long network of intermediaries - wholesale and retail companies	Small agricultural producers are forced to transfer industrial goods to wholesale networks, often below their cost due to the lack of direct access to store shelves. The selling price of such products in the case of low quality is quite high relative to the level of real available income.	The introduction of advanced digital technologies in agricultural enterprises can significantly reduce transaction costs in the case of buying or selling goods, as well as minimizing the supply chain

Continuation of Table 1.

Barriers	Content	Solutions
Low level of development of communications and IT infrastructure	Currently, the territory of agricultural land in Russia is not sufficiently covered by communication networks, which is why it is sometimes impossible to ensure the transmission of data by various digital devices in real time	Placement of communication facilities by the state, by entrepreneurs - development and investment in appropriate infrastructure, for example, laying new communication lines or building facilities
Lack of IT solutions localized for the agro-industrial complex	The developed localized IT solutions for implementation at the enterprises of the agricultural sector are currently not available on the Russian market. Therefore, enterprises are faced with a situation where various separate offers can be presented on the market, but without the possibility of adapting such solutions to their needs or without the possibility of integrating such solutions among themselves in the enterprise.	Widespread adoption and dissemination of various types of modern digital technologies, such as cloud applications, Internet of Things technologies, big data management services, upgrading of communications used in rural areas, and finally, the development and implementation of an agricultural equipment rental model
Staff shortage	There are not enough qualified personnel	Development of the personnel training and incentive system

Source: [5, 6, 7, 8].

The existing difficulties, in particular those associated with insufficient infrastructure support for the agricultural industry, are not a significant obstacle for large agricultural enterprises that seek to carry out digital transformation on agricultural land under their control. To a certain extent, the fulfillment of this task becomes a matter of survival for agribusiness, since they need to ensure the sale of their products in the face of changing consumer behavioral attitudes, which are dictated by the desire to purchase high-quality and safe goods and, at the same time, to reduce the anthropogenic pressure on the environment by transferring agriculture economy on the "green economy" [1, 11, 12].

Practice shows that large agricultural enterprises are active participants in the digitalization process. For example, John Deere, Trimble, Iteris Inc. companies are already using digital technologies for crop mapping, field work management, and collecting data on the state of sown areas using drones , aircraft, and sensors [9].

7 Discussion

Among European countries, Germany occupies the first place in the digital transformation of agriculture. In this country, the solution of issues related to the digitalization of agricultural production falls within the competence of the Federal Ministry of Food and Agriculture (BMEL), which, on the one hand, stimulates transformational processes in the agro-industrial complex and, on the other hand, studies the consequences of digitalization, and also contributes to the achievement of balance between increasing the efficiency of the use of crop areas through the introduction of ICT and protecting the environment. The main direction of

digitalization of agriculture in Germany is the integration of precision farming and smart farm systems into the activities of agricultural enterprises and subsidiary plots. This is accompanied by regular updating of hardware and software, which contributes to the optimization of agricultural processes, improved interaction between business entities and faster delivery of products to the end consumer. At the same time, the question of the profitability of digitalization of medium and small agricultural enterprises remains relevant for the German agricultural sector; however, until this problem is fully resolved, the Ministry of Food and Agriculture uses all the resources available to it to promote innovative developments in the field of agriculture.

Taking into account the experience of Germany, we can conclude that the digital transformation of agriculture shall be carried out by improving the agricultural infrastructure necessary to collect and process large amounts of data on the state of the external and internal environment; strengthening ties between personal subsidiary plots, large agricultural enterprises and the government; exchange of innovations between the states of the European Union and other world powers. With this approach, the effectiveness of the ongoing reforms is significantly increased, which, in turn, creates prerequisites for the further strengthening of German agriculture.

An interesting project was implemented in Switzerland, where an agricultural organization system was presented, which is based on the automated management of production and economic processes that accompany the activities of agricultural enterprises. As this system was created, Swiss researchers studied the specifics of the impact of transformation processes on the general state of the agricultural sector , on the productivity of agricultural workers, and also on the environment. The monitoring results allowed specialists to compile a list of the most and least effective digital tools that can be used in real agricultural production.

In Ireland, the introduction of the smart farming model is ensured through the implementation of the government program of the same name, which has been in force since 2014. Its main task is to integrate automated and mechanized solutions into the activities of farms, focused on reducing costs and reducing harmful emissions. 1,900 farms became participants in the program: on average, each of them saved 5,000 thousand euros, including by reducing fuel costs by 10%.

Swiss experts also note that the introduction of smart farming tools helps to reduce the anthropogenic burden on the environment. The reason for this is the constant and high-precision monitoring of the state of sown areas, during which a large amount of data is accumulated, which is necessary for a clear determination of the volumes of fertilizers and pesticides applied. Monitoring of the most important indicators of the external environment is carried out by installing and configuring a network of sensors that collect information about plants, animals, soil, climate and other elements of the biosphere, which allows modeling maps of the distribution of adverse natural phenomena and pests, as well as predicting meteorological processes. All this helps to use natural resources efficiently and develop the optimal technology for growing crops, thereby increasing the profitability of farms and reducing the adverse human impact on the environment.

A feature of the digitalization of agriculture is that this sector of the economy most of all needs the creation and implementation of technologies that ensure the collection and processing of spatial data. This approach allows accelerating the process of making important management decisions that determine the key goals of the agro-enterprise, its capabilities and needs in interaction with other participants in the agro-food system, and reserves for sustainable development. In addition, regular monitoring of spatial data, which is the basis of the smart farming system, contributes to the creation of conditions for the cultivation of high-quality and safe products that will be in demand among consumers in the highly competitive market for agricultural products. Also, the introduction of smart farming tools

ensures the transparency of the production process, which gives buyers the opportunity to track all stages of the passage of products “from field to counter”. All this has a positive effect on the transformation of the agricultural sector and the strengthening of interaction between agricultural enterprises and consumers [9,10].

Despite the existing difficulties, the digital transformation of agriculture is also taking place in Russia. A significant number of "smart farms" are located in the Moscow region: for example, the dairy farm of the Zelenogradsky plant, where production is fully robotized. The farm uses such innovative developments as a feed pusher robot, an automatic harvester, an intelligent “smart doctor” system and other automated mechanisms that allow serving a herd of 200 heads.

The agro-industrial complex is developing no less actively in Siberia. The key direction of digitalization of agricultural enterprises in this region is the introduction of information and communication technologies in the processes of agricultural management. Thus, in the Altai Territory, since 2015, a unified electronic automated system for providing measures of state support for agricultural producers has been launched, which since 2017 has been supplemented by the RusGIS geoinformation system used to assess the efficiency of the use of sown areas. It shall also be noted that in the agriculture of the Altai Territory, more than 660 thousand hectares of arable land are covered by advanced technologies, which is approximately 10% of its total area.

The digital transformation of the agro-industrial complex of this region leads to significant positive results: for example, in the Rodinsky farm, due to the introduction of satellite navigation equipment, its own weather station and precision farming tools, it was possible to increase the yield of individual crops by more than 3 times. Another large enterprise, Agrofirma Urozhay, which uses precision farming technologies, has demonstrated an increase in winter crop yields by 25% (up to 54 centners per hectare). At the same time, the processes of digitalization of the agro-industrial complex of the region are also being implemented in the form of separate projects - for example, the greenhouse complex " Tolmachevsky " has introduced into its activities the project "greenhouses on the roof" developed in Novosibirsk, the basis of which is constant monitoring of the indicators of the microclimate of greenhouses and the concentration of carbon dioxide, which allows timely water plants, supply nutrient mixtures and mineral fertilizers, regulate the ventilation system.

At the same time, the agro-industrial complex of Russia needs to increase the volume and pace of digitalization of agriculture. To achieve this goal, it is necessary to integrate domestic digital technologies that already exist and are used in practice into the agro-food system, namely:

- ExactFarming is a platform that brings together digital agronomy solutions for agricultural enterprises, manufacturers and sellers of fertilizers, agrochemicals and seeds, financial institutions and other entities in the agricultural sector. The use of this platform allows industry participants to improve the quality of agribusiness management by making optimal management decisions, strengthening intra-industry ties, and minimizing risks and threats.
- "Agrotronik" is a set of agronomic services developed by the Rostselmash Group of Companies, which includes round-the-clock monitoring technologies, precision farming tools, video systems, etc.
- Cognitive Technologies is a software that integrates applied solutions for agriculture.
- "AgroMon" is a software package that includes a web service and a mobile application, which is used to manage field work through the cooperation of all subjects of agricultural (including crop) production.
- SmartAGRO is an agro-enterprise management system based on a set of software models that automate business processes in an agricultural organization.

- "History of the field" is a cloud service from the Geomir company, which allows you to control field work by regulating the state of sown areas and the operation of agricultural machinery.
- NeuroPlant is an assistant for collecting, storing and operational data analytics based on artificial intelligence technology that describes the production and economic processes at an agricultural enterprise.
- "SkyScout" is a unified information system for managing an agro-enterprise, which provides manual and automatic collection of information about the state of sown areas and crops
- DigitalAgro is a set of tools and services that collect and process information about the environment, followed by the preparation of analytical conclusions that are used in making key management decisions that determine the goals and objectives of agricultural producers.
- "Agrosignal" is a digital platform and mobile application for managing an agricultural enterprise, which is used to optimize the main production and business processes implemented in the course of field work, crop rotation planning, reporting, budgeting and developing a strategy for the development of agricultural production.
- Green Growth is a digital platform that allows you to map yields in real time based on the data obtained from the analysis of each section of the field.
- "Polydon Agro" is a mobile application that reflects information about the products of the agrochemical manufacturer of the same name. The mobile service includes a mixing calculator needed to formulate complex fertilizers.
- "Own farming" is a web service from Rosselkhozbank , developed on the basis of e - commerce, which simplifies the process of trade within the agricultural sector by creating a single catalog of seeds, fertilizers, agrochemistry and even agricultural machinery.

The activity of such IT companies as:
- CenterProgramSystem is a leading developer of software for agricultural management.
- Avrora Robotics is a manufacturer of mechanized control systems for agricultural machinery.
- Magrotech is a developer of a software package used to collect and process data on the state of sown areas, as well as for mathematical modeling of crop yields.
- Assistagro LLC is a manufacturer of unmanned aerial vehicles for collecting, storing and operational data analysis in order to make optimal management decisions when organizing agricultural work.
- Kaipos LLC is a manufacturer of meteorological monitoring systems, modeling maps of the spread of pests and diseases of plants, irrigation optimization technologies.

The further development of digital platforms and technologies for agriculture shall be accompanied by an improvement in data protection systems and an increase in the performance of individual web services and applications. The implementation of this approach will minimize the risks of digitalization of agricultural enterprises and eliminate barriers that impede the active digital transformation of the domestic agricultural sector. Also, an important direction in the modernization of agricultural management is the improvement of the methodology for processing and analyzing big data, which contributes to the formation of full-fledged systems for tracking production in the agro-industrial complex and optimizing the process of making managerial decisions [1].

8 Conclusion

The introduction of digital technologies in agriculture reduces risks and increases the profitability of agricultural enterprises by improving the agricultural management system and reducing the negative impact of internal and external factors.

The digitalization of agriculture involves the following main tasks:

- creation and development of a unified electronic system for the provision of public services to agricultural producers;
- integration of digital methods for monitoring crop areas;
- digitization of fields;
- introduction of a precision farming system;
- equipping agricultural machinery with satellite navigation systems.

The implementation of the proposed measures contributes to an increase in the efficiency of the use of natural resources and the production of agricultural products, which creates additional advantages for agricultural producers both in the domestic and foreign markets.

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