Introduction of digital technologies in the agro-industrial complex as a tool for ensuring sustainable development of rural areas

Pavlov A.Yu.
Penza State Technological University
Penza, Russia
crsk@mail.ru

Batova V.N.
Penza State Technological University
Penza, Russia
batova.v.n@yandex.ru

Popov V.V.
Saratov State Law Academy
Saratov, Russia
vpopov@sgap.ru

***Abstract* — Growing demand for agricultural products and solving the problems of food security of the countries of the world require the introduction of new technologies in the agro-industrial complex, contributing to improved productivity and food quality. According to a worldwide survey of PwC Digital IQ for 2017, IoT technologies are in the first place in the ranking, taking into account the level of investment in innovation that can change the business models of companies. In this regard, the article discusses the directions of development of IT-technologies in the agro-industrial sector and the dynamics of investments for 2014-2016, as well as the stages of the introduction of IT-technologies in yield management in the farm. Particular attention is paid to the implementation in Russia of the Internet of Things (IoT) technology and the implementation of the international program of agricultural robotization, Ural Cognitive Agro. The main barriers to the implementation of automation in rural areas and the need to expand the activities of operators from the provision of communication services to complete solutions for the agricultural sector in the field of IoT have been identified.**

Keywords — digital economy, information technology, unmanned vehicles, agriculture, rural areas.

I. Introduction

Innovative economic development is a strategically important area of state policy in modern conditions, which creates the basis for the dynamic growth of the national economy, changes its structural characteristics, determines its international competitiveness and overall viability (Pavlov, Batova, Kovalyova, Kolesnikov, Sokolov and Soboleva, 2015). The modern period of development of the Russian Federation is a new technological era, which is caused by a number of fundamental changes that penetrate into all areas of socio-economic processes.

One of these areas is agriculture, which forms the fundamental basis of the economy of any country (Latysheva, 2018). The transformation processes taking place in the agrarian regions of Russia in recent decades require new approaches to regional development. (Belousov, Pavlov, Batova, Sokolov, Kolesnikov and Vyushkina, 2016).

For a long time, agriculture was not a business attractive for investors due to the long production cycle, subject to natural risks and large crop losses during cultivation, harvesting and storage, the inability to automate biological processes and the lack of progress in improving productivity and innovations. The use of IT in agriculture was limited to the use of computers and software mainly for financial management and tracking commercial transactions. Not long ago, farmers began using digital technologies to monitor crops, livestock and various elements of the agricultural process. Technology evolved and a sharp jump in interest in the segment occurred when technology companies paid attention to agriculture, who learned, together with partners, to control the full cycle of crop or livestock production through smart devices that transmit and process the current parameters of each object and its environment, as well as seamless communication channels between them and external partners. Thanks to the integration of objects into a single network, the exchange and management of data based on the Internet and the increased productivity of computers, the development of software and cloud platforms, it became possible to automate the maximum number of agricultural processes by creating a virtual (digital) model of the entire production cycle and interrelated links of the value chain, and with mathematical precision, plan the work schedule, take emergency measures to prevent losses in the event of a recorded threat, calculate the possible yield, production cost and profit.

Until recently, the use of IT in agriculture was limited to the use of computers and software mainly for financial management and tracking commercial transactions. Farmers have now begun to use digital technology to monitor crops, livestock, and various elements of the agricultural process (Shaporova and Titovskaya, 2018).

The importance of the digitalization of the agro-industrial complex is related to the fact that the agrarian sector of the economy ensures the food security of the country, solves the problems of import substitution and sustainable development of rural areas. In the conditions of transition to the sixth technological order, new tasks are set for it, the solution of which will determine its existence (Kapeliuk and Aletdinova, 2017).

In July 2017, the Presidential Council for Strategic Development and Priority Projects approved the Digital Economy program, which, according to President Vladimir Putin, will allow Russia to make a breakthrough into the future. As the President noted: “Digital economy is not a separate industry, in fact it is a way of life, a new basis for the development of the system of government, economy, business, social sphere, the whole society. The formation of the digital economy is a matter of national security and independence of Russia, the competition of domestic companies. ”

The project for the development of the digital economy in Russia is on a par with such large-scale transformations as mass railway construction in the 19th century and electrification of the country in the first half of the 20th century. According to the president, the digital economy will become the basis for reforms across the country and will affect every company and every citizen of Russia. This is essentially a way of life, the basis for the development of the system of government, economy, business.

The intensive introduction of digital technology and the Internet of things into agriculture promises to turn the industry, less affected by IT, into a high-tech business due to the explosive growth of productivity and reduction of unproductive costs that are attributes of agriculture 4.0.

Agriculture is becoming a sector with a very intensive data flow. Information comes from various devices located in the field, on the farm, from sensors, agricultural engineering, meteorological stations, satellites, drones, external systems, suppliers. General data from various participants in the production chain, collected in one place, allows you to receive information of new quality, find patterns, create added value for all involved participants, apply modern scientific processing methods and make the right decisions based on them that minimize risks that improve manufacturers' business.

II. Research Methodology

During the study, the authors analyzed information on the development of digitalization in the agricultural sector. Information search was conducted among the scientific literature, in which 16 sources were identified.

In addition to the scientific literature, the authors analyzed the legal acts containing the regulations for the development of the digital economy in the Russian Federation, as well as the official websites of the Government of the Russian Federation, the President of the Russian Federation, websites containing statistical data, the website of the Federal portal of legal acts of the Russian Federation. The following research methods were used:

- induction method - in formulating logical conclusions by generalizing observation data, as well as in obtaining general conclusions based on private premises, when moving from the particular to the general;
- deduction method - when obtaining private conclusions based on general knowledge, as well as in formulating conclusions from the general to the particular;
- the system approach method - when considering the whole as a complex of interrelated elements;
- comparative analysis method - when comparing the level of labor productivity and the use of information technologies by farmers in agriculture in Russia and other countries of the world.

Based on the findings of the study, the authors identified a number of problem areas in the development of the digital economy in agriculture of the Russian Federation, and also developed measures to eliminate them.

III. Research Results

Efficient and systematic use of innovative digital assessment methods, technologies and tools led to an understanding of the special priority of theoretical study and a gradual practical transition to a new level of the economy (Rassadin, Pavlov, Batova and Kolesnikov, 2014). The relevance of the digital transformation of the agricultural economy, both at the level of a separate agricultural business and at the level of branches of the agro-industrial complex economy, forms a growing interest in problems and opportunities, risks and benefits that become relevant in the digital economy (Udalov and Udalova, 2018).

In Russia, there is at least a threefold reserve for increasing grain yield in comparison with the United States and Germany. The lag in the level of labor productivity in agriculture as a whole compared to Germany is 3 times, with the United States - more than 20 times. In Russia, the gross value of agricultural products per employee in 2015 amounted to USD 8 thousand, in the USA - USD 195 thousand. This is due to the extremely low level of mechanization and the use of fertilizers, as well as a large proportion of peasant farms and small farms (99% of the total), which do not have the financial capacity to purchase new equipment, use connected equipment and introduce agroinnovations.

In this regard, improving the efficiency of agriculture is one of the priorities of the socio-economic development of modern Russia, as reflected in the Digital Economy of the Russian Federation program approved by the decree of the Russian government dated July 28, 2017 No. 1632-r. In order to implement the Digital Economy technologies, the program envisages the improvement of the communications infrastructure that ensures the interaction of robots with the environment and among themselves. According to a study conducted by PricewaterhouseCoopers (PwC), the cumulative economic effect from the introduction in Russia of the Internet of Things (IoT) technology will be about 2.8 trillion rubles by 2025, including 469 billion rubles in agriculture (Internet of Things Future technology available today, 2017).

It is assumed that these technologies will increase labor productivity and competitiveness of the agro-industrial sector, taking into account the growing demand for agricultural products. Unmanned systems installed on tractors and loaders, in addition to reducing the influence of the human factor, have another significant advantage: they minimize the risk of theft of fuel and grain. Accurate positioning systems also help reduce overlap, reduce fertilizer and chemical overruns.

As the first project of implementation of measures for the introduction of IoT technologies in the agricultural sector, it should be noted the international program of agricultural robotization "Ural Cognitiv Agro", launched in 2017 by Cognitive Technologies and the Ural Federal University (UrFU). According to company forecasts, the economic effect of the program will be at least 20-30 billion rubles. due to the introduction of robotics in the application to the tasks of smart agriculture ("smart" agriculture).

In August 2017, Cognitive Technologies, for the first time in Russia, tested an unmanned combine harvester in the Rostov Region. To implement the project, the Cognitive Agro Pilot automatic driving system was installed on an experimental model of the RSM 181 Torum combine (manufacturer - Rostselmash). As a result, the developed computer vision technology for automatic driving of a combine harvester was able to determine the folded roll better than a man and move along the edge of the field. The basis of the development is the technology of deep learning of neural networks, or deep learning. In addition, in the Russian project, the set of sensors was only one video camera, unlike foreign analogues, which use laser scanners to move along the edge of the field and stereo cameras to work on rolls, which reduces the cost by three to four times. This competitive advantage is especially important for entering international markets.

With the possibility of unmanned driving, Russian combines will be able to compete on equal terms with the world's leading agricultural brands, which already have a similar function.

Experts of the Ural Cognitive Agro program calculated that with the stated dates for the start of the program for the period until 2022, the lag behind the leading countries in key labor productivity and productivity indicators (by a factor of 2.5-3) can be practically eliminated.

It should be noted that currently there is a certain infrastructure for the implementation of IoT solutions - data networks, data processing centers (DPCs) and computing resources for collecting, storing and processing large data arrays, however, they have not been adequately developed in rural areas and are mainly concentrated in large cities. The main barrier to the introduction of automation in rural areas is currently insufficient coverage of agricultural land by communication networks.

As of 2016, in the AIC of the country, the use of information technologies is carried out only by 20% of agricultural enterprises, mainly large ones, whose land area is more than 20 thousand hectares. The conduct of modern agriculture in a developed information society involves the continuous receipt of information from various external sources (via the global Internet) from anywhere in the area at a convenient time.

Thus, one of the hallmarks of the use of information technologies in farms is the presence of computers, as well as their connection to the Internet (Table 1). (Semilyakova, 2014).

TABLE I. THE USE OF INFORMATION TECHNOLOGY BY FARMERS

Country	Number of full-time farmers	Number of farmers using computers		Number of farmers working on the Internet	
		ppl.	*%*	*ppl.*	*%*
Denmark	60,000	48,000	80	30,000	50
Finland	80,000	50,000	62.5	40,000	50
Norway	70,000	52,000	74.3	40,000	57.1
Sweden	30,000	24,000	80	14,000	46.7
Russia	275,000	9,000	3.3	3,000	1.1

As you can see, an example of the intensive use of information technologies is the EU countries, since the number of computers connected to the Internet (about 50%) far exceeds the Russian figure. In this regard, the role of telecommunications operators will expand from the provision of communication services to the provision of complete end-to-end solutions for the agricultural sector in the field of IoT (Houlin Zhao and Chuck Robbins, 2016).

IV. THE DISCUSSION OF THE RESULTS

According to FAO UN forecasts, the development of agriculture in the near future will be one of the most promising global areas. To meet the needs of the increased population by 2050, the world will need 70% more food than was produced in 2006. For agriculture, this means a regular and ever-growing demand for agricultural products, as well as the emergence of a number of new challenges and fundamentally new requirements for the level of productivity in general (Gerard Sylvester Information and communication technologies for sustainable agriculture. Indicators from Asia and the Pacific,2013).

The development of "smart agriculture" aims to automate agricultural activities as much as possible, to increase the yield and product quality. Figure 1 shows the main directions that can change agriculture in the future (E-agriculture strategy guide. Piloted in Asia-Pacific countries, 2016).

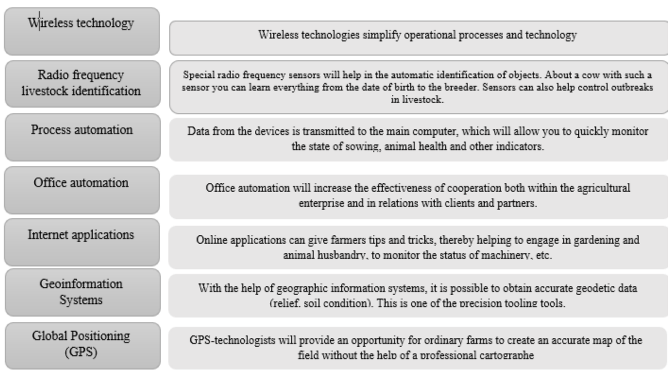

Fig. 1. Directions of development of IT-technologies in the AIC

In 2010, there were no more than 20 high-tech agricultural companies in the world, and for the period 2014-2016. Already, about 1,370 new technology start-ups totaling more than $ 10 billion have been invested (Table 2).

TABLE II. DYNAMICS OF GLOBAL INVESTMENT IN AGRICULTURAL TECHNOLOGIES FOR 2014-2016.

Years	**The largest investment segments**	**Total investment, billion dollars**	**Number of business deals**	**Number of investors**	**US share, %**
2014	- Grocery marketplace / e-commerce; - Bioenergetics; - Technologies to monitor the state of the earth and plants	2.36	264	271	90
2015	- Grocery marketplace / e-commerce; - Irrigation solutions; - Drones	4.6	526	672	58
2016	- Grocery marketplace / e-commerce; - Biotechnology; - Seed removal technologies; - Applications (software) for farm management, sensors, IoT	3.23	580	670	48

A new investment segment, AgTech (AgroTech), has been formed, which in 2014 overtook FinTech and CleanTech. The general term AgroTech combines various equipment and technologies based on receiving and processing data, both within the agricultural production cycle and beyond, used to increase productivity, efficiency and profitability (Ovidiu Vermesan and Peter Friess, 2013).

In addition to the USA, Canada, India, China, and Israel are showing noticeable activity in this segment. A long value chain of agricultural products and a large number of unsolved problems in the industry that can be solved with the help of IT and automation is one of the main reasons for the investment attractiveness of the industry (Linli Zhou, Liangtu Song, Chengjun Xie, and Jie Zhang, 2013) .

According to Gartner, the total economic effect from the introduction of the Internet of things in all sectors of the economy on a global scale will amount to 1.9 trillion dollars by 2020. Agriculture accounts for 4%, i.e. about 76 billion dollars.

The average farm is expected to generate about 4.1 million data points per day by 2050, compared with 190 thousand in 2014, and will evolve from the usual data collection organization to the programmed automatic farm management based on them (Figure 2) .

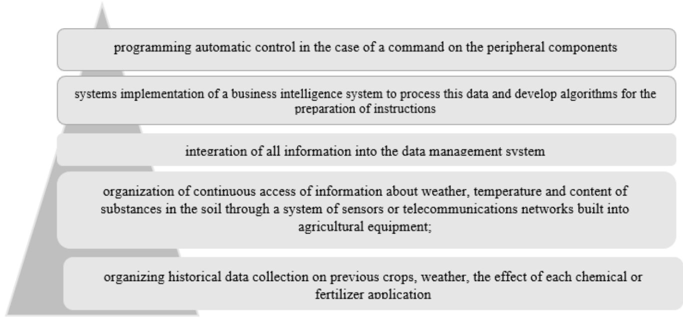

Fig. 2. Stages of implementation of IT-technologies in farm yield management

V. CONCLUSIONS

The largest operators (AT & T, Telefonica, Verizon, Orange, Deutsche Telekom, Vodafone, etc.) now offer farmers specialized wireless equipment, sensors and sensors, analytical platforms, solutions for diagnosing devices, etc. They become a key part of the system, ensuring the availability of applications and the safety of their use. At the same time, cooperation with full-scale IoT platforms gives the operator access to new markets and new customers.

According to the GSMA, the level of participation of mobile operators in projects in agriculture in 2015 in the world was only 17% against 81% in the automotive industry. The most important obstacle to the use of 3G/4G cellular networks in agriculture is insufficient coverage in rural areas, high costs for building a network from scratch and high energy intensity of technologies. However, the relatively low level of involvement of operators creates prerequisites for their more active participation in the future.

In Russia, the IoT technology system is only being formed. As noted, mainly projects with elements of the Internet of Things are launched by large agro-industrial complexes with private capital and state support. Meanwhile, solutions for small farms and even for amateur gardeners are developing in the world.

Despite the fact that in developed countries, the intensification of agriculture through the use of IoT technologies can lead to negative consequences for employment, in the Russian Federation the introduction of IoT can be a solution to the problems of rural development due to low population density. The use of unmanned vehicles will contribute to a more efficient use of arable land, the involvement of new territories in agriculture (Karpunin, 2016).

Minimizing the losses that market players are currently suffering is only one component of the IoT economy. The potential long-term effect is much wider, it is related:

- both with cost optimization (due to savings in consumables and resources), which will affect margins and, consequently, the competitiveness of companies,
- and with new opportunities to increase revenue due to increased yields (according to various estimates, from 10 to 20%) and product quality.

Acknowledgment

The reported study was funded by RFBR according to the research project No. 19-010-00859 A.

References

[1] Karpunin B. (2016) Using information technology in the agriculture of Asia-Pacific Economic Cooperation (APEC) economies and beyond. Global Forum on Food Security and Nutrition, Summary of the online discussion. 134.

[2] E-agriculture strategy guide. Piloted in Asia-Pacific countries (2016) Published by the Food and Agriculture Organization of the United Nations and International Telecommunication Union, Bangkok: 207 p. (http://www.fao.org/3/a-i5564e.pdf)

[3] Gerard Sylvester Information and communication technologies for sustainable agriculture. Indicators from Asia and the Pacific (2013) Food and Agriculture Oorganization of the United Nations regional office for Asia and the Pacific, Bangkok: 104 p. (http://www.fao.org/3/a-i3557e.pdf)

[4] Houlin Zhao and Chuck Robbins (2016) Harnessing the Internet of Things for Global Development. International Telecommunication Union Place des Nations, Geneva: 61 p. (https://www.itu.int/dms_pub/itu-s/opb/pol/S-POL-BROADBAND.15-2015-PDF-E.pdf)

[5] Internet of Things Future technology available today. (2017) PricewaterhouseCoopers Advisory offices in Moscow: 14 p. (https://www.pwc.ru/ru/publications/IoT_English_version.pdf)

[6] Linli Zhou, Liangtu Song, Chengjun Xie, and Jie Zhang (2013) Applications of Internet of Things in the Facility Agriculture. CCTA, Part I, International Federation for Information Processing (IFIP): 297–303.

[7] Ovidiu Vermesan and Peter Friess (2013) Internet of Things: Converging Technologies for Smart Environments and Integrated Ecosystems. River Publishers: 363 p.

[8] Semilyakova Kristina (2014) Application of information technology in agriculture. Naukarastudent.ru, 12. (http://nauka-rastudent.ru/12/2246/)

[9] Latysheva A. I. (2018) Information infrastructure of innovative agricultural projects. ITportal. 1(17). (http://itportal.ru/science/tech/informatsionnaya-infrastruktura-inn/)

[10] Shaporova Z. E. and Titovskaya N. V. (2018) Digitalization in agriculture is a breakthrough in the future. Science and education: experience, problems, development prospects. Proceedings of the international scientific and practical conference: 96-98.

[11] Udalov A. A. and Udalova Z. V. (2018) Development of integration processes in the conditions of digital transformation of the economy of agriculture. Innovations in agriculture. 4 (29): 392-399.

[12] Kapeliuk Z. A. and Aletdinova A. A. (2017) The Main challenges of the development of the Russian agricultural sector. Far Eastern agricultural Bulletin. 4 (44): 198-203.

[13] Pavlov A.J., Batova V.N., Kovalyova N.N., Kolesnikov A.V., Sokolov A.Y. and Soboleva Y.V. (2015) Problems of state regulation of innovation policy in the Russian Federation and foreign countries. Journal of Advanced Research in Law and Economics. (6): 802-821.

[14] Rassadin V.V., Pavlov A.J., Batova V.N. and Kolesnikov A.V. (2014) Evolutional-genetic approach to formation of sustainable development indicators of the agricultural territories. Journal of Environmental Management and Tourism. 2 (10): 230-236.

[15] Belousov S.A., Pavlov A.Y., Batova V.N., Sokolov A.Y., Kolesnikov A.V. and Vyushkina E.G. (2016) Neo-endogenous model of overcoming imbalances in economic - legal framework of Russia agrarian regions as a factor of economic security. International Journal of Advanced and Applied Sciences. 3(4): 20-24.