# Agriculture 4.0: Application of the Internet of Things and Digital Technology in the Agro-industrial Complex*

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**Abstract.** The paper focuses on the rapid development of new technologies in the agricultural sector, including the Internet of Things, thin technologies, robotics. All of the, became the directions of development of the 4th industrial revolution in the agro-industrial complex. The proliferation of the Internet, wireless networks, adequate cost of equipment (sensors, sensors, computers) provide growing opportunities for the implementation of this technology and reduce the cost of components. This article is an overview of the main challenges in agriculture at the current stage of development, an analysis of the prospects for using the Internet of Things in the agro-industrial complex, an examination of the main technologies and drivers of development, as well as an analysis of the barriers hindering the spread of digital technologies in agriculture. In other words, the aim of the study is to analyze the current development of digital technologies in agriculture in general and in the development of the Internet of Things in particular.

**Keywords:** Internet of Things, Agricultural sector, Digital technologies, Agro-industrial complex, Agriculture 4.0

## 1 Introduction

The industrialization and development of information technologies expand the opportunities for economic growth and the development of the digital economy. The present period of development is characterized by the rapid development of new technologies in the agricultural sector. The Internet of Things, thin technologies, robotics became the directions of development of the 4th industrial revolution, which also affects agriculture [3; 13]. In the period 2017-2022, one expects the growth of the IoT market in the agro-industrial complex at the level of 16-17% [10]. Experts are planning a prolonged effect from the introduction of IoT

technologies in the agro-industrial complex, which will be associated with saving resources and materials and also optimizing costs [2]. Due to the growth of agricultural production, there is a need to revise the method of administering the production of rural products. Numerous studies show that the development of digital technologies increases efficiency in related areas of the economy. The introduction of digital technologies in agriculture is currently considered one of the methods to enhance the efficiency of administration and development.

Informatization has become a lever of influence on economic entities in Russia, leading to widespread digitalization of various sectors of the national economy. Agriculture of Russia pays great attention to precision farming, using information, telecommunication and satellite navigation systems for collecting and processing information, and innovations of high technologies. The solutions developed and used include pest control systems, as well as planting and replacement of heavy tractor equipment, intensively compacting the soil, precision fertilization systems, and irrigation. With a significant decrease in the comfort of weather and soil-climatic conditions of agricultural landscapes, the consumption of specific energy spent on the production of crop production increases, and therefore the adaptively differentiated use of biological, technogenic, chemical factors for intensifying agricultural production becomes more relevant [8]. Agriculture can be considered as the lowest-endowed branch of the economy in relation to modern information and computer technologies. Russia is currently in 15th place in the digitalization of the agrarian economy, having great potential in land, labor and natural resources [4].

Analysts claim that 80% of agricultural enterprises in the Russian Federation will have to use digital solutions in their work in 10 years [1]. The prerequisites for the widespread introduction of IT technology in the agricultural sector include: the peculiarities of the agricultural economy as a sector of the national economy, technological diversity, the complexity of production processes controlled by IT technologies, the scattering of controlled parameters, and population growth.

The approaches and methods of digitalization make it possible to automate processes that were not planned for automation until recently. In addition to technologies using artificial intelligence and other intelligent systems in agriculture, the concept of a computer network equipped with technologies for interaction between special intelligent devices and the environment is a very fast-growing phenomenon [21]. The Internet of Things is considered in this article as a network of objects that exchange information between servers. The proliferation of the Internet, wireless networks, adequate cost of equipment (sensors, sensors, computers) provide growing opportunities for the implementation of this technology and reduce the cost of components. This article is an overview of the main challenges in agriculture at the current stage of development, an analysis of the prospects for using the Internet of Things in the agro-industrial complex, an examination of the main technologies and drivers of development, as well as an analysis of the barriers hindering the spread of digital technologies in agriculture. In other words, the aim of the study is to analyze the current development of digital technologies in agriculture in general and in the development of the Internet of Things in particular.

## 2 Materials and Methods

### 2.1 Challenges in agriculture

Agriculture is one of the poorest sectors of the national economy in terms of the introduction of modern technological, computer and computer technologies. Russia is in 15th position in digital agriculture, despite the fact that the country has enormous potential in terms of labor and natural resources. The growth of population and prosperity will objectively provoke an increase in consumption. Russia is the leading country in terms of increasing arable land. With changes in the economy and technology, the introduction of new methods and technologies in the agro-industrial complex is a paramount task.

The level of productivity in agriculture determines a number of factors: socio-economic factors (technical skills, conditions of activity), introduction of innovations, dissemination of best practices and experiences, the use of modern methods for growing plants and animals, new materials, protective chemicals, and biotechnology applications. From the point of reducing losses and increasing efficiency in agricultural production, innovative production methods are of great importance for the food security of the regions and the country as a whole.

By combining the efforts of science and business, it is possible to create the most innovative industry in Russia. According to experts, companies that actively use innovative technologies in their business can achieve a significant increase in yields and become leaders in the agricultural market. By 2050, 70% more food will need to be produced. Achieving this goal with limited land resources will be possible due to the introduction of new technologies, and increasing production efficiency and productivity. Reducing costs and increasing production profitability is possible only with the use of the latest technologies at the enterprise.

The territory of Russia, on a fairly large area, is an agricultural zone at risk, exposed to natural and climatic, soil, biological, and geographical factors, which leads to high administrative costs. Consequently, the application of innovative technologies and the spread of the use of the Internet of Things in agriculture is an acute and important theoretical and practical problem.

## 3 Results and Discussion

### 3.1 Application of the internet of things ans digital technology in agriculture

Agrarian farms have historically not used high technologies, but it is planned to significantly increase their use to millions of gadgets by 2025. According to the forecast of Pricewaterhouse Coopers, the minimum effect of the introduction of new

technologies in the agro-industrial complex from reducing losses in crop production by 2025 will amount to 469 billion rubles [17]. The digitalization of the agro-industrial complex provides for the production of high consumer quality products. Agriculture 4.0 creates dynamic communication systems that increase productivity and reduce production costs. Automation and digitization of a large number of processes in agriculture is a conscious necessity in the development of the world's largest engineering and agro-industrial companies.

IoT is a key technology in smart farming as it allows data to be exchanged between sensors and other devices, which adds value to information obtained through automated processing, analysis and access, enabling faster and more cost-effective farm management [15]. The IoT allows real-time monitoring of the emergence of weeds, pests, diseases, monitoring of hazardous weather or soil conditions. Such advances lead to the reduction and adequate use of resources, including fertilizers or protective equipment. Agricultural IoT applications benefit from the monitoring and administration of many parameters in an operational, open context using heterogeneous automated components. Thanks to the use of IoT, the agricultural economy becomes manageable, that is, decisions are made in real time, reducing uncertainty and inefficiency, and thereby reducing the negative impact on the environment.

The main innovative solutions that characterize the concept of intelligent agriculture are: precision agricultural production; unmanned ground vehicles; autonomous wireless sensors; digital control simulation; cloud technologies. The sensors can be used on farms and agricultural machinery [12]. Agriculture in developed countries pays attention to using telecommunication and satellite navigation systems for collecting and processing information, including the practical use of high-tech innovations. Among the adopted solutions, one could mention pest control systems, planting and replacing heavy tractors, soil compaction, precision fertilization systems, irrigation. Using the Internet of Things to monitor water use for optimal plant growth and to determine soil moisture and nutrient content is the most common application for the Internet of Things [9].

The use of IoT technologies in agriculture opens up wide opportunities for performing the following tasks: monitoring, documenting, forecasting, and managing. Monitoring is the timely measurement of various parameters and, as a rule, is the main starting point for other tasks. The documentation covers storing experimental data for later use, for example, in farm management. Forecasting uses a variety of data sources using analytical methods to predict specific events and mathematical models.

The use of precision farming technologies based on the Internet of Things is a consequence of increasing yields on a large scale. For the first time in history, it became possible to obtain information about any agricultural object, draw up an accurate mathematical algorithm of actions and make a forecast of the result. Monitoring the physical health of plants and soils is one application, but it can lead to a great return on investment for farmers in the industry through the use of sensor technology [14].

Considering the main parameters allows solving the problems of the timing of field work, including the yield of arable land. This allows farmers to obtain a useful

set of data, such as the amount of fertilizer, food, water in the soil and planted seeds, the temperature of stored products, the status of agricultural machinery and equipment in use, and much more [6]. Simultaneous tracking and control of characteristics over a large area is accompanied by considering territorial features, which does not serve as a positive factor for data collection. The introduction of IoT in crop production automates the control of climatic parameters, soil characteristics, minimizes human participation in technological operations of product production [18]. The emergence of "smart" devices makes it possible to control the productivity of crops, considering changes in the growing environment.

High technologies and automation are also used in animal husbandry. The Internet of Things monitors the physical condition of animals. For instance, a system developed by IT company Fujitsu is called "connected cows". A sensor on the animal is used to keep track of measurements. Animal activity data are recorded, analyzed, and relayed. Milking and feeding of animals are also fully monitored. Animal diseases are detected at the earliest stage due to the fact that a sick animal moves less [11]. Another example, farms in the Tyumen region of Russia have an automatic milking system. The agricultural enterprise of the Ishim region uses an analytical management system in animal husbandry. The system automatically analyzes and presents the results of the collected samples to monitor changes in animal health. The system automatically identifies diseases, monitors the reproductive system, and controls for healthy diet. As a result, the technology increases the longevity of production processes [7]. Some startups use artificial intelligence and IoT to optimize pig feeding. A computer vision system helps companies to monitor and analyze all conditions and movements of animals at the stage of breeding and feeding, as well as to perform automatic head count and remote weighing of each animal. This system even analyzes cases and daily weight gain, and tracks pig behavior for early disease detection [16].

Information systems and neural networks analyze more events and improve business efficiency. In general, farmers face two main tasks: to maximize income and reduce costs, while maintaining the high quality of the product. At an agricultural enterprise, an information cloud is being created for the exchange of data of analytical and administrative structures in the non-stop mode of IT systems, and such a cloud is necessary for the development of IoT. The use of IoT technologies is modifying management and governance in agriculture [5]. The introduction of big data technology, the use of unmanned vehicles, self-propelled vehicles, the use of sensors can modify agricultural holdings into smart farms.

The prolonged effect of the introduction of high digital technologies, including the Internet of Things, in the agricultural sector is the saving of budget and materials, and lower production costs. New technologies increase both yields and profits, which means that the competitiveness of agricultural production goes up. With a decrease in the comfort of soil and climatic conditions, the specific energy consumption spent on the production of agricultural products increases; therefore, the adaptive differentiated use of biological, technological, and chemical factors for intensifying agricultural production becomes more relevant [19].

In sum, the automation of agricultural economy on techno-platforms and the introduction of the Internet of Things are the determining factors in the development

of agriculture in the world and in Russia. The current upward trend in food supply is enabling the industry to move from a conservative industry to a high-tech one capable of innovating the Internet of Things. Promising areas are sowing, harvest forecast, remote sensing, and differentiated irrigation [20]. Pulling payloads from data volumes collected by IoT devices requires data mining on M2M platforms.

### 3.2 Barries to the adoption of the internet of things and digital technology

There are a large number of problems in agriculture that impede the faster and more efficient dissemination of information technology and the Internet of Things in Russian agriculture. For example, one can mention the uneven quality of cellular communication in agricultural areas, the lack of a software platform for data exchange, and the lack of funds to invest in digitalization in farms. Of course, the lack of funding for digital agricultural modernization is the most pressing challenge of all. In our opinion, it is necessary to create a common platform and mechanisms for attracting investors and strengthening public-private partnership in the agricultural sector. For the digitization processes to be effective, it is necessary to carry out systematic and high-quality monitoring, which is currently difficult at the level of cities and regions. An important systemic problem is the lack of preparedness of economic agents and managers to use digital processes due to a lack of human resources, a shortage of staff, a lack of digital skills in leaders and visions of the digital future. The set of the described problems characterizes the qualitative state of the institutional environment for the use of digital technologies in the agricultural sector.

## 4 Conclusion

The Internet of Things, information technology, robotics determine the key directions of the 4th industrial revolution, which is unfolding before our eyes in agriculture. Technologies automate human work, speed up data processing, and solve management problems in agriculture. Lower costs and higher profitability of agricultural production in the new environmental and socio-economic conditions arising from the increased demand for food become associated with the concept of smart agriculture. It is based on innovations that automate agricultural activities as much as possible through intelligent solutions, reducing the need for human participation in the production cycle. This reduces the risk of negative consequences and provides control over production technologies. The introduction of IoT technologies in the agricultural sector automates the control of the parameters of temperature and humidity of soil and air, minimizes human participation in agrotechnical operations of agricultural production.

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