Analysis of expectations and level of awareness of farmers on the application of IoT technologies in agriculture

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Abstract. A quantitative assessment of the expectations of farmers regarding the increase in the profitability of production as a result of the introduction of these technologies is given. For this, a survey was conducted of managers and specialists of 47 agricultural organizations in the Middle Urals. According to the results of the survey, it was found that only 6.7% of respondents stated that they received more than 10% of information using digital devices. At the same time, 54.3% of respondents are concerned about the leakage of data on the activities of an organization connected to the Internet when using IoT technologies. The areas of application of IoT technologies, in accordance with the answers of respondents, are related to the use of IoT technologies to control the consumption of resources (water, electricity, fuel, etc.) (23.4% of answers), remote control of machines and equipment (20.6%), forecasting crop yields and animal productivity (14.0%), monitoring conditions on farms (13.1%) and others. The main problems in the application of IoT technologies are the lack of free funds (25.0% of all answers) and the high cost of implementing IoT technologies (17.7%). A significant proportion of respondents (20.2%) indicated a low level of state support, which slows down the pace of implementation of IoT technologies. In general, one can note the low level of awareness of farmers about IoT technologies. The results of the study make it possible to identify barriers and limitations of the use of IoT in agriculture, to outline ways to overcome them.

1 Introduction

Currently, IoT technologies are used in various industries. For example, in medicine, a platform is used to develop a monitoring system for the detection and prevention of chronic diseases, including diabetes, obesity or depression [1]; various sensor systems for remote determination of patient vital signs [2, 3, 4]. IoT is used in various environmental monitoring systems [5, 6, 7] using touch sensors. There are a number of smart city solutions based on IoT for data flow forecasting [8, 9], vehicle traffic monitoring [10], home tracking animals [11], descriptions of human behavior in crowded places [12], energy efficiency improvements through communication between different categories of objects [12]. In

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industry, IoT technologies are used to improve communication reliability [13], optimize energy consumption [14, 15, 16, 17]. In trade, IoT is used to build supply chains in the shortest possible time [18], including the operation of real-time ERP systems [19], improve the accuracy of customer service recommendations [20].

Internet-connected IoT devices are predicted to increase from 23 billion today to 75 billion by 2025 [21]. As IoT technology advances, digital tags will be placed at facilities around the world, including 20 million shipping containers, 300 million LED lights, 1.8 billion water meters, over 4 billion herd animals. This will make the "smart world" a reality and stimulate completely new ways of developing society, improve the efficiency of various sectors of the economy, from industry to such a conservative sector as agriculture.

In accordance with the program for digitalization of agriculture in the Russian Federation, “images” of digitalization of agriculture have been formed (Ministry of Agriculture of the Russian Federation, 2017). According to the plan of the program developers, companies operating platforms that provide support for the production of agricultural products in terms of IoT technologies and equipment management, “digital field”, “digital herd” applications should operate on the market. By 2024, all domestic manufacturers of tractors and combines must be equipped with controllers that meet international standards and allow the use of domestic-made attachments. According to this program, the share of agribusiness enterprises using IoT technologies, incl. precision farming, digital herd and smart greenhouses, should increase to 60% by 2024. At the same time, the share of jobs related to information technology, data processing and cyber-physical systems in rural areas should increase to 20% by 2024.

2 Materials and methods

To assess the awareness and expectations of farmers, a survey of managers and specialists of 47 agricultural organizations in the Middle Urals. The next stage focused on a survey of 47 farmers of the Middle Urals. The respondents were selected randomly from the total number of 246 agricultural businesses, thus accounting for 19.1% of the quantity and allowing us to see the sample as representative. The average age of respondents was 46.5; 83.0% of them were male and 17.0% – female. Most (83.0 %) of the respondents have higher education; 10.6 % have a bachelor’s degree; 4.3 % have a master’s degree; one respondent has a degree of candidate of sciences. The above businesses were arranged in groups by different characteristics. In accordance with the Russian laws, companies can be classified by size into small, medium and large, depending on the number of employees and revenues. By the number of employees, 36.2 % of the total number of the companies participating in the survey can be classified as micro business; 17.0 % – as small business (with the number of employees ranging from 16 to 100 people); 23.4 % – as medium-sized business (with the number of employees ranging from 101 to 250 people) and as large business (with the number of employees exceeding 250 people). By their revenues, 57.4% of the companies can be classified as micro business (with revenues reaching 120 million rubles); 38.3 % – as small business (120 - 800 million rubles).

3 Results

The definition of the concept of IoT (Internet of things technologies) is important. We consider it appropriate to expand the semantics of this concept. Given the specifics of the industry, the following concept can be proposed: IoT technologies in agriculture are a set of devices, sensors that transmit information in real time from various agricultural production facilities over the Internet to tools for collecting, managing and storing data, and processing

them into useful information provided to users through the appropriate interface.

The assessment by managers and agricultural specialists of the possibility of using IoT technologies is important.

Increasing the feasibility of using IoT technologies in agriculture increases with the increasing role of information. To date, there are a large number of variables and restrictions that allow you to get a digital picture of any event in the production sector. The construction of various models is possible using a large amount of data and analytics. Until now, there was no way to measure, collect and process this data. IoT technologies increase the number of data entry points by an order of magnitude, and the use of computer hardware and software makes it possible to comprehend this information.

By some estimates, machine-generated data currently accounts for about 15% of all data in large organizations [22]. This figure is expected to rise to 50% in the future.

It is important to estimate the amount of information received by agricultural executives and specialists from meters, sensors and other digital devices (Fig. 1).

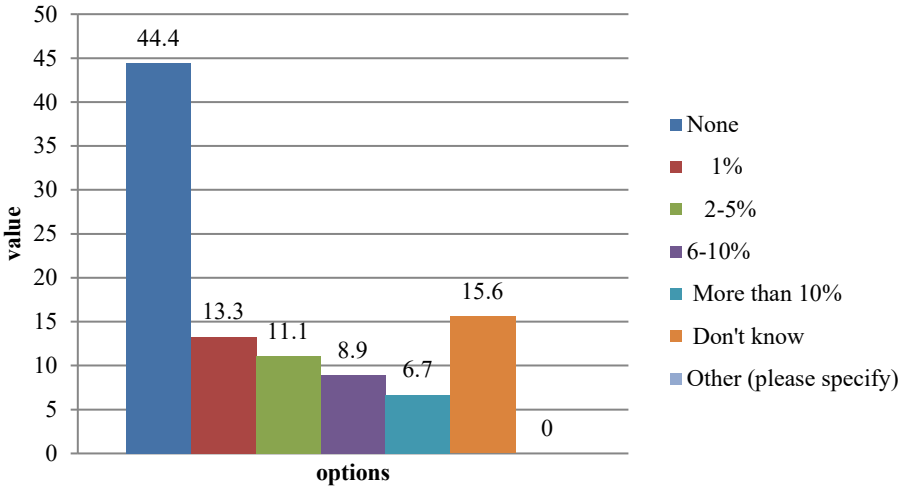

Fig. 1. Information received by farmers by using meters, sensors and similar technical devices
Source: authors, the respondents' opinion

The survey found that 44.4 % of the farmers did not use meters and sensors for collecting information; 15.6 % of the respondents found it difficult to answer the question. Only 6.7 % of the respondents informed that more than 10% of the information was received by them with the help of digital devices. The application of IoT technologies can frequently involve sharing information about activities of a company with public users. Information can be shared through the company's website and its availability depends on the willingness of agricultural companies to share this information with public users. The survey showed that 17.0% of the respondents said that their companies did not have any website or that they saw no reason to have it. 54.3% of the farmers have concerns about leakage of information about the activities of the Internet-connected company using IoT technologies (Fig. 2).

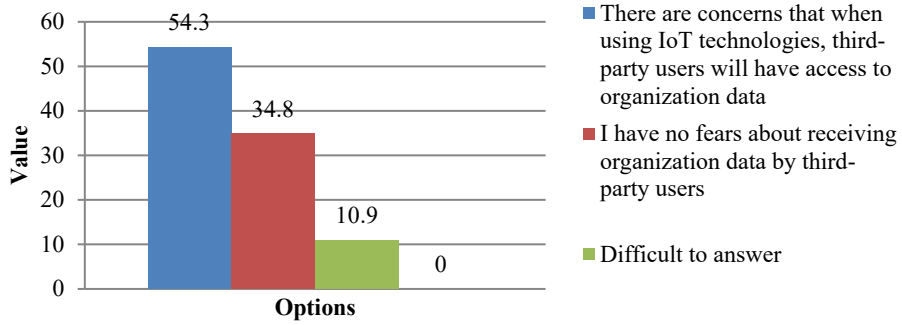

Fig. 2. Farmers' concerns about leakage of the company's information
Source: authors, the respondents' opinion

Therefore, the survey detected high concerns about possible information leakage caused by application of IoT technologies. The survey results are almost the same as the findings (Gemalto, 2018) where 60% of the respondents are concerned about IoT-caused data breaches. It can serve as a rationale for further studies on IoT security. The main objectives in IoT security include protection of confidentiality of a company's information, security of users, infrastructure, data and IoT devices as well as availability of services offered by the IoT ecosystem. Studies in IoT security have been gaining fresh impetus with the help of available modeling tools.

Adopted and emerging IoT technologies can be instrumental in assessment of prospects for IoT application in agriculture. The most probable IoT agricultural applications were selected with reference to the previously obtained information on the related research areas. The respondents were also asked to offer their own answer for IoT applications not mentioned in the list (Fig. 3).

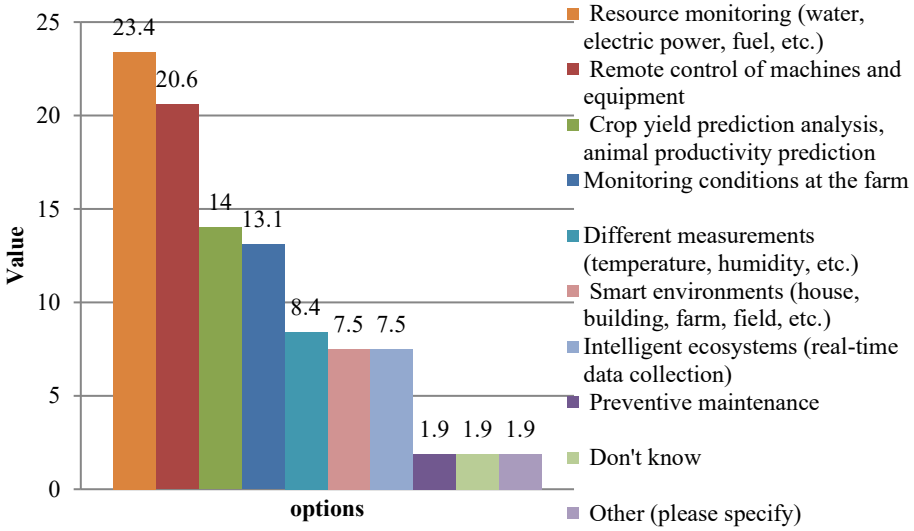

Fig. 3. The most probable IoT applications in the farmers' opinion
Source: authors, the respondents' opinion

Most of the farmers (23.4 %) think that IoT technologies can be used to monitor consumption of resources, including water, electric energy, fuel, etc. Profound interest

(20.6 %) was demonstrated in IoT-supported remote controlled machines and equipment. Contrary to expectations, smart environments (a smart house, smart farm, smart field, etc.) as well as intelligent ecosystems involving real-time data collection did not capture strong interest of the respondents (7.5%). Quite a few of the respondents (14.0 %) were interested in IoT technologies making it possible to predict crop yields and livestock productivity as well as to monitor conditions at farms (13.1 %). Farmers' preferences tend to depend on organizational, economic, natural and other specific characteristics of a certain region; thus, they need to be further studied.

The expected benefits of using IoT technologies are shown in Figure 4.

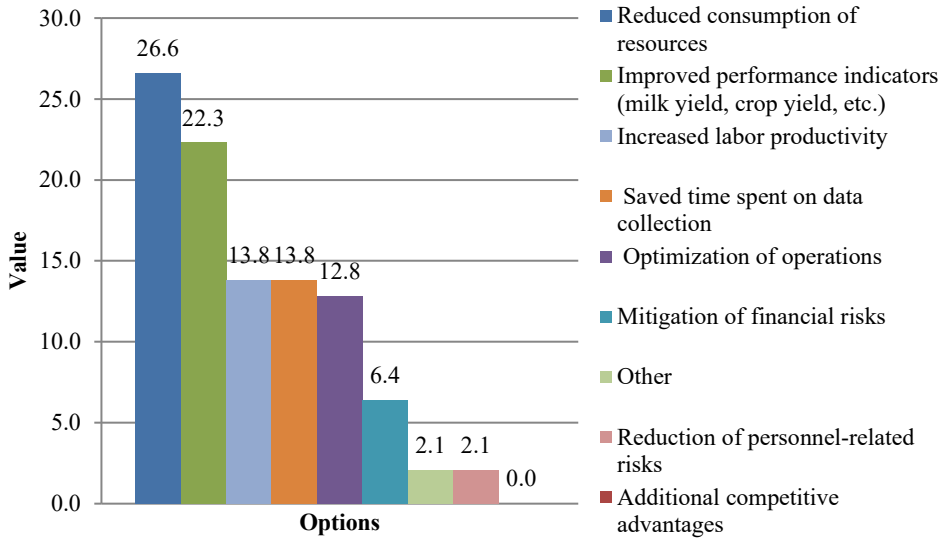

Fig. 4. Expected benefits of using IoT technologies – the farmers' opinion
Source: authors, the respondents' opinion

Most of the benefits are expected from reduced consumption of resources (26.6%), possibility to improve business performance (22.3 %), reduced number of mistakes, improved labor productivity, time saving (13.8 %). The overwhelming majority of respondents (53.2%) mentioned increased profitability of production; 21.3% of them expect that the profitability will increase by 5 – 9%, 10.6% of the respondents expect a 20% and higher increase due to IoT adoption (Fig. 5).

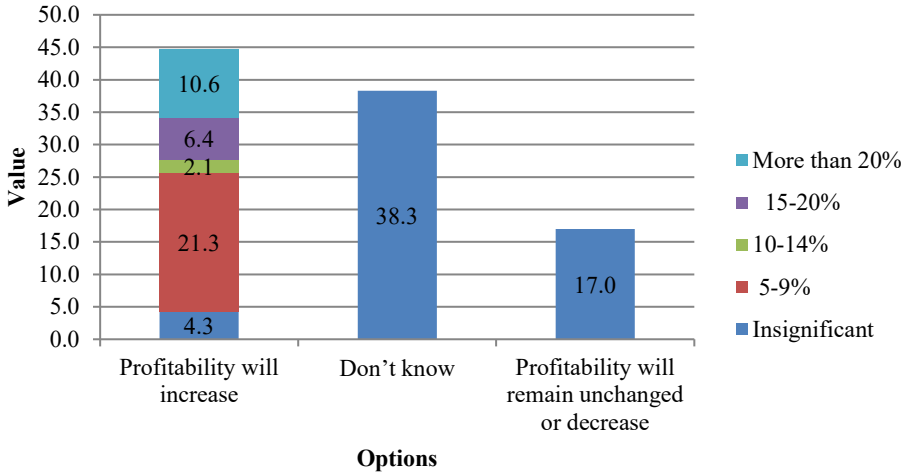

Fig. 5. Expected increase in production profitability due to IoT technologies – the farmers' opinion
Source: authors, the respondents' opinion

Quite a few respondents (17.0%) were skeptical about using IoT technologies. A large number of respondents (38.3%) found it difficult to answer the question. Most apparently, it can be explained by the novelty of these technologies and by the farmers' poor awareness of opportunities offered by IoT adoption.

Using IoT technologies in agriculture can be associated with a number of barriers and natural constraints. The farmers think that the main problems are a lack of readily available funds (25.0% of the respondents) and high IoT adoption costs (17.7%). Note that the adoption costs can significantly vary – from several thousand rubles (for example, installation of a soil temperature and moisture sensor) to several hundred thousand and million rubles (for example, installation of the network of mobile weather stations) (Fig. 6).

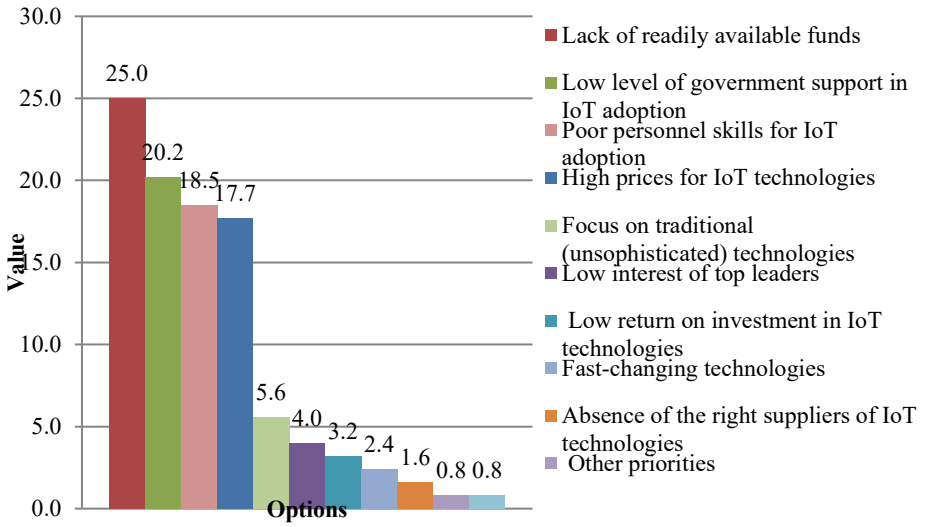

Fig. 6. Main barriers and challenges in using IoT technologies – the farmers' opinion
Source: authors, the respondents' opinion

To assess possible barriers to the use of IoT technologies, respondents were offered ten

different answer options, and were also asked to formulate their own answer if none of the proposed ones fit. A substantial proportion of respondents (20.2 %) mentioned the low level of government support affecting the pace of IoT adoption. The priority areas for government support include subsidies for development of dairy and beef production, crop production, machines and equipment, etc. In the meantime, sophisticated innovative technologies, including IoT technologies, are not subsidized. Besides, a considerable proportion of IoT components is made by foreign manufacturers; these components do not have domestically produced alternatives, thus complicating reimbursement of expenses on their adoption. The company adopting IoT technologies needs a respective design team, which should also include employees of this company. However, poor personnel skills across the industry, as noted by 18.5 % of the respondents, present a severe challenge.

Both large manufacturing companies and small companies having projects in high-tech areas act as suppliers of IoT technologies. The market already has proven IoT technologies in monitoring of consumption of fuel, seeds and fertilizers during the sowing season, monitoring of microclimates in livestock buildings and storage facilities, different on-animal sensors for monitoring animal behavior, etc. It is notable that 98.4 % of the respondents had no difficulty finding the right suppliers (Fig. 7).

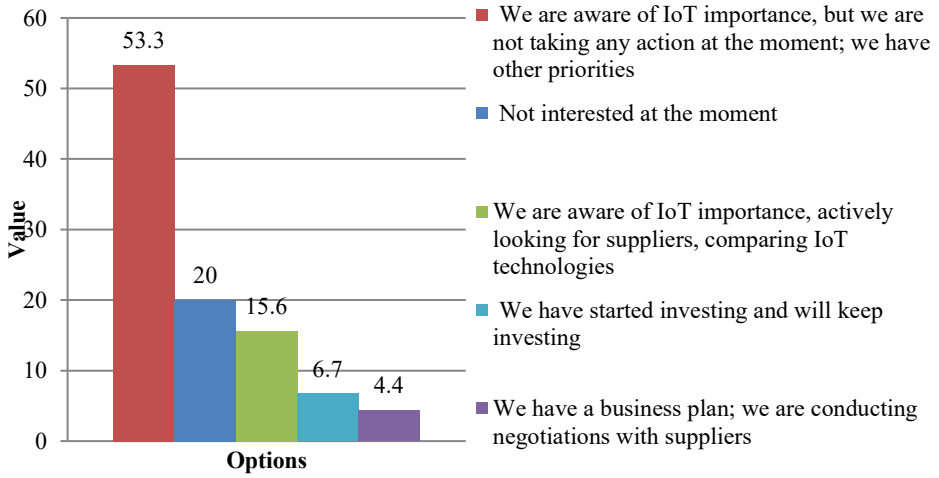

Fig. 7. Middle Ural farmers' preparedness for IoT technologies
Source: authors, the respondents' opinion

The conducted survey also addresses companies' preparedness for using IoT technologies in their agricultural production. The survey showed that only 6.7 % of the surveyed companies use these technologies, while a considerable proportion (53.3 %) takes no action in this area.

4 Discussion

The application of IoT technologies in agriculture, based on narrowband Internet technology, will gradually increase. The widespread use of sensors will make data warehouses unnecessary, and data will be integrated from every plant, every animal, every farm and every stage of production. All information - from plant and animal health, biological cycles to production volumes and data on water supply, processing, transportation, safety control and other stages of agricultural production will serve as sources of information for the application of "smart" technologies. Together with hundreds

of millions of connections, such data will increase the productivity of large agricultural organizations. By 2025, more than 1 billion cows will have "digital tags" connected to the network. 525 million farms worldwide will use about 600 million IoT connected sensors.

5 Conclusions

It is important to note that the possible multiplier effect of the introduction of IoT technologies in Russia depends on the systemic nature of the state approach: updating the regulatory framework, improving support mechanisms, creating conditions for developing human resources, consolidating and coordinating industry communities. Currently, there is an increase in the number of state initiatives in this direction, although not all of them have yet been implemented in practice. In the case of a thoughtful and systematic approach, IoT can become a significant factor in the growth of agricultural production in the long term.

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