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Data-driven approach in digital agriculture: survey of farmers

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***Abstract*—The issues of increasing the efficiency of agriculture are relevant in connection with the growth of the world population. One way to solve this issue is to collect and analyze big data to support decision-making in the industry of crop production. Such an approach can allow a farmer to monitor the condition of their farmland, save resources (water and chemicals), respond quickly to emerging problems and increase yields. The purpose of this study is to reveal the level of awareness and understanding, as well as the opinion of farmers about the introduction of data science technology in agriculture. This study demonstrates the results of a survey of farmers in the Astrakhan region, conducted in 2017 and 2019. The results revealed the barriers to the implementation of big data technologies, as well as the conditions under which farmers are ready to introduce appropriate innovations into their business. High costs of implementation, lack of relevant specialists in the region, poor infrastructure development and insufficient understanding of key technologies by the business owner were identified as the main barriers. Farmers see financial support from the state, as well as the availability of qualified specialists among the main conditions for the introduction of digital technologies in agribusiness.**

***Keywords*— big data, digital agriculture, data science, smart farming, precision**

I. Introduction

Modern technologies of data collection and analysis make it possible to increase business efficiency at different stages of development. It can effectively operate in the field of agriculture (plant growing). Data from agricultural fields can be collected, for example, by sensors (or the wireless network of sensors) of soil condition (for example, the soil temperature, humidity, salinity) and using small weather stations that can also monitor the environment. In addition, data from fields can be collected with unmanned aerial vehicles (the drones) from an aerial view, assessing the condition of the vegetation using a special spectral camera. The data collected in this way can be processed using machine learning algorithms. Based on the data analysis, it is possible to monitor the status of the fields, identify and predict problems by examining the results of analysis on a computer screen or mobile phone, and also forecast the yields for the season.

The purpose of this study is to reveal the level of awareness, understanding and knowledge of farmers' opinions on the implementing of big data technologies in agriculture.

Within the scope of the study, the following research questions are addressed:

1. Do farmers know and understand the techniques of data collection and analysis in agriculture?

2. Are farmers ready to implement technologies for data collection and analysis in their agribusiness to support decision-making and improve business performance?

3. What are the barriers to the introduction of methods for collecting and analyzing data in agribusiness?

II. Literature Review

Large amounts of data with great variety can be collected, processed, analyzed and used to support decision-making in agriculture. The scope of Big Data applications in agriculture was reviewed by Wolfert et al. [1]. Researchers emphasize that the main sources of big data (sensors, robots (machine-generated data), and social media (human-sourced data)) can provide access to more complete information, expanding the possibilities for decision-making. Different factors that can drive the development of Big Data for agriculture were described in detail. In addition, the authors recall that there are many innovative start-up companies that develop products in the field of data analysis and sell them to farmers.

Li, Chen, and Guo [2] consider agricultural data as a sort of typical big data and propose the flowchart of intelligent processing of agricultural Big Data. Kshetri [3] discussed the opportunities and challenges of using Big Data applications in agriculture. Several authors believe that Big Data is the root of a new revolution in farming (e.g. [4]).

A farmer can receive data from several sources that can be combined and presented in a convenient form to support decision-making. Currently, several solutions have been developed for farmers in this area (e.g. [5]). An example of the functional architecture of a farm management system addressing advanced characteristics of the "Future Internet" (a program launched by the European Commission [6]) was described by Kaloxylos et al. [7]. The authors believe that a farm management system can make a farmer a new "node in an agricultural worldwide web" [7, p. 141].

Recent publications in this area highlight the interest in developing farm management information systems to meet changing conditions and the development of new technologies (e.g. [8], [9], [10]). For example, a Harvest Management Information System is used for collecting real-time harvest and labor data, transferring it to the cloud platform, and analyzing and visualizing data collected [9, p. 164]. The system can develop yield maps, visualize the productivity of the farm, and explore the factors of influence on the crop.

Several studies in the area of digital agriculture included interviews with experts in agriculture. Pivoto et al. [11] conducted an expert interview with specialists in the agricultural industry in order to identify attitudes towards new technologies and their use in the agro-industry (Brazil). The Australian experience of farmer attitudes towards the use of sensors and automation in agriculture was described in a study by Bramley and Ouzman [12]. The authors emphasize the presence of a positive effect in the use of sensors in precision agriculture (203 surveys were conducted). Cho in his description of digital farmer [13] highlights the challenges and opportunitites of a farmer's digital qualities, such as having a personal retraining program and strategies to invest in new technologies. Erickson et al. [14] conducted a survey of US farmers, through which they studied the minimum educational requirements (knowledge, skills, abilities) for effective work in digital agriculture. The researchers emphasized the importance of obtaining the necessary skills both at additional training programs and within university programs. In this case, the content of education programs should take into account the specifics of the industry and technology trends coming into agriculture.

III. Materials and Methods

The main element of this study is a questionnaire. The study involved farmers from the Astrakhan region (Russia) at the age of 18 or above. The survey was conducted twice. The first survey took place in March-April 2017 (42 participants), the second - in February-March 2019 (32 participants). The questionnaire was created on the basis of the research objective; literature review was also considered. The questionnaire was used in paper and electronic form, in which the purpose of the study is indicated additionally. Participation in the survey was voluntary and anonymous.

It is worth noting that during the time period between the two surveys, a number of activities in the field of digital technology took place. First, the Digital Economy program was launched in Russia, and this program also addresses aspects of digital agriculture. Secondly, projects related to digital agriculture (in particular, drones for agriculture, sensor systems), developed by researchers at Astrakhan universities, began to appear at agricultural exhibitions held in the Astrakhan region.

IV. Results and Discussion

A. Farmer's Understanding and Readiness

Questions of the questionnaire address the aspects of farmers' understanding and readiness to introduce technologies for big data collection and analysis in agriculture in order to increase business efficiency.

Results and comparison of indicators for different years are shown in the Table I.

Comparison of the results on understanding the concept of data collection and analysis in agriculture shows an increase in the basic understanding of this approach. However, there is a decline in deeper knowledge (24% in 2017 versus 12% in 2019). This may be due to the fact that farmers realized a certain complexity and multilevelness when introducing digital technologies in agriculture and realized that they have only basic knowledge in this area. This could be facilitated by scientific seminars held for farmers of the Astrakhan region as part of additional educational programs.

TABLE I. Farmer's Understanding and Readiness

2017	2019
Understanding the concept	
• Understand most of the concept – 24% • Basic understanding – 17% • Do not understand – 59%	• Understand most of the concept – 12% • Basic understanding – 72% • Do not understand – 16%
Smart farming can improve the business?	
• Agree – 72% • Disagree – 2% • Neither agree or disagree – 26%	• Agree – 75% • Disagree – 0% • Neither agree or disagree – 25%
Ready to implement new technologies?	
• Agree – 19% • Disagree – 24% • Neither agree or disagree – 57%	• Agree – 50% • Disagree – 6% • Neither agree or disagree – 44%

Understanding the benefits of smart farming to increase the efficiency of agribusiness remained at about the same level. This may be directly related to an increase in the degree of readiness of farmers to introduce new technologies in their agribusiness (increase in agreement with this opportunity from 19% in 2017 to 50% in 2019).

B. Barriers and Conditions for Implementation

The results of the analysis can be interpreted as a commitment of farmers to traditional technologies of agricultural business, but with the possibility of increasing its effectiveness through new technologies. Farmers, of course, have barriers to the implementation of new technologies. The main barriers are high implementation costs, absence or lack of appropriate specialists, lack of necessary expertise from the owner of business, and lack of infrastructure (Fig. 1).

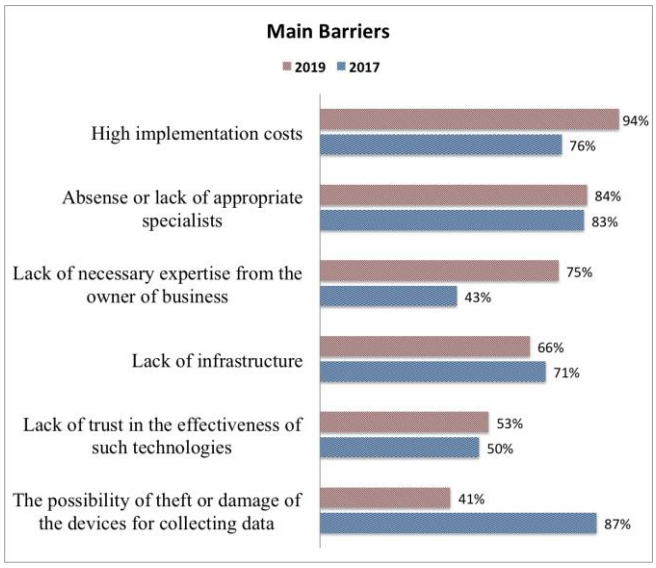

Fig. 1. Main barriers.

Comparison of the results of 2017 and 2019 shows that the importance of such factors as the high costs of implementation and the lack of knowledge of the business owner has increased. This may underline the fact that, on the one hand, farmers realize the importance of introducing new technologies in agribusiness and it is important for business owners to understand the essence of these technologies and their place in the development strategy. On the other hand, the issues of financing such innovations that may imply substantial capital investments come to the fore, especially in the presence of a large area of agricultural fields.

These barriers directly affect the conditions under which farmers are ready to implement technologies for data collection and analysis in their business (Fig. 2).

Farmers see help from the state as the main source of financing. These may be subsidies for the development of farming or access to concessional loans. The significance of this factor has grown. In addition, farmers are more willing to invest their own money (the growth rate over 2 years from 5% to 19%). This is underlined by the growing understanding of the importance of introducing data collection and analysis technologies in agribusiness, as well as an assessment of improving business efficiency, reducing some costs and improving competitiveness in the medium term.

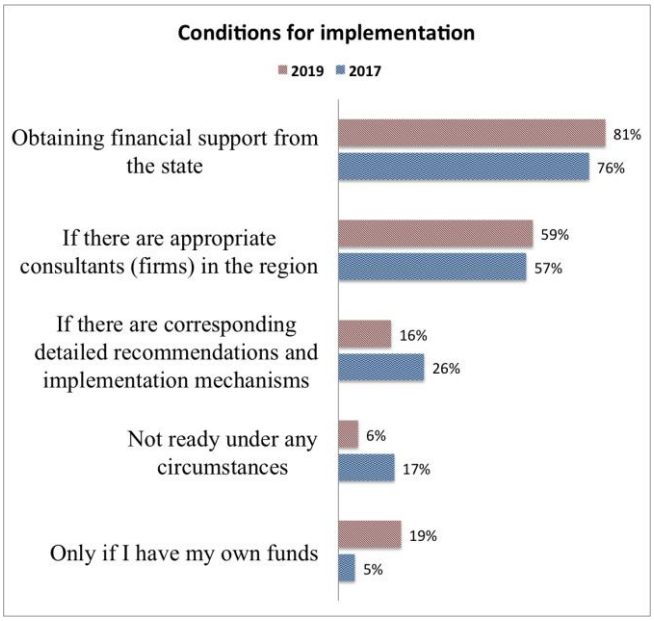

Fig. 2. Conditions for implementation.

The availability of specialists and firms that can advise farmers on the introduction of digital technologies in agribusiness (and take part in relevant projects) remains the most important factor among the conditions for implementation. As emphasized earlier, higher education institutions and the regional ministry of agriculture, in partnership with large agricultural companies, should work together on this task. This joint activities, on the one hand, can accelerate the process of introducing technologies in agriculture, and, on the other hand, this interaction will be the motivation to prepare highly qualified specialists for the regional agricultural sector.

V. Stages and Data Sources

One of the most important goals of the questionnaire was to learn in which stage, according to farmers, it can be efficient and appropriate to use technologies of data collection and analysis. The most popular answers (stages) are shown in Fig. 3.

The most popular data sources for farmers are soil condition (including soil moisture, temperature, and level of fertilizers), weather data (and its forecast), and vegetation condition.

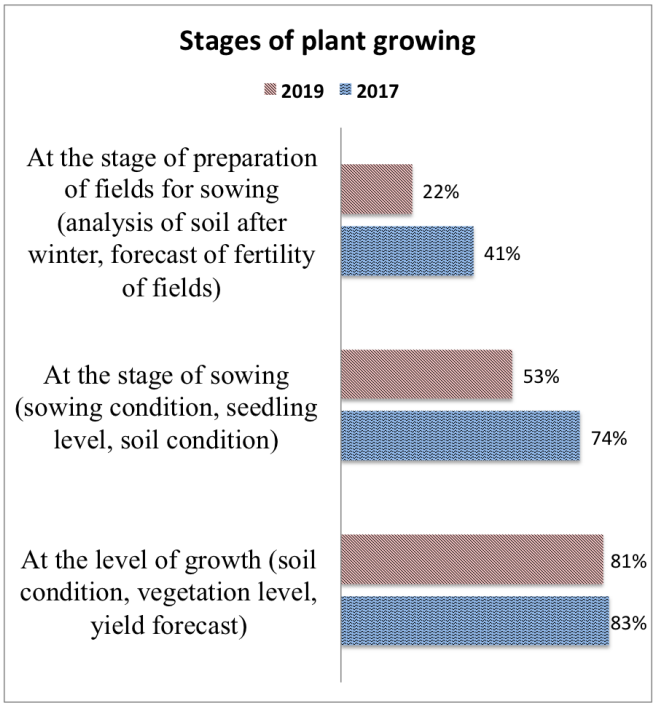

Fig. 3. Stages of plant growing.

According to farmers, an important advantage in using a data-oriented approach is the ability to quickly eliminate problems associated with crop growth (operational monitoring of germination, soil moisture, pests, identification of plant diseases) and resource optimization (water, fertilizer). This includes the financial, environmental and human aspects. From a financial point of view, this may imply a reduction in the likelihood of losses due to a delayed response to problems of germination and growth. The environmental aspect involves careful attention to the soil and the environment in terms of rational use of water and minimizing the use of chemicals. Elements of automation and predictive analysis can help reduce the negative impact of the human factor (lack of qualified professionals, errors in calculations, neglect of work duties, etc.).

VI. Conclusion

This study has revealed the level of understanding, awareness and willingness of farmers to introduce big data technologies into their business. There are a number of barriers to innovation in agriculture, but these barriers can be overcome by using the right approach. The main barriers are the high costs of implementation, the absence or lack of relevant specialists, the lack of necessary experience of the business owner and the lack of infrastructure. Collaboration between farmers, universities, the regional ministry of agriculture and large agricultural companies can contribute to minimizing these barriers.

For more effective implementation of such innovations in agriculture, government support is needed as part of the development of support programs. Science and modern research should also be in constant contact with the business. This can help popularize new approaches to doing business, create conditions for training specialists who are able to solve business problems using digital technologies. The scientific community and regional universities need to pay special attention to the development of the agricultural sector in the region, providing appropriate advice and participating in joint projects. Successfully implemented pilot projects in the field of digital farming in one company can become a benchmark for other companies in terms of mechanisms for the implementation and economic efficiency of digital agricultural technologies.

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