The study of the advantages and limitations, risks and possibilities of applying precision farming technologies

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Abstract. The introduction of precision farming technologies at agricultural organizations in Russia is proceeding at a slow pace, that makes it necessary to find ways to intensify this activity. The study aims to identify opportunities, threats, strengths and weaknesses and develop scientific and practical recommendations on strengthening the use of precision farming technologies in agriculture. Agricultural experts were involved in assessing these characteristics. The strengths include raising awareness of agricultural managers and specialists about the progress in work performed (the conditional index is 4.13 points) and reducing the consumption of material resources (3.83 points). The introduction of these technologies is encouraged with the availability of the Internet at rural areas (3.56 points). The greatest concern is about the functional and physical depreciation of the material and technical base (3.98 points) and insufficient government support (3.44 points). It is necessary to develop governmental targeted measures on increasing state support for updating the material and technical base of agriculture, restoring the human capital in the industry, and developing technologies for precision farming of domestic (Russian) production, which will reduce the dependence on exchange rate fluctuations.

1. Introduction
Currently, agriculture in Russia is targeted to introduce production systems aimed not only at increasing yields, but also at reducing the negative impact on the environment with consideration of the agro-ecological characteristics of agricultural land and maximizing profits. These conditions have promoted the introduction of agricultural innovations that are known as precision agriculture or precision farming. These developments were based on research and approaches that consider various processes and characteristics of agricultural production, and also enable the development and introduction of appropriate methodologies and technologies in accordance with the objectives. Precision farming technologies consider the spatial and temporal variability of the agroecosystem in order to increase economic efficiency; increase the productivity of agricultural crops; improve the quality of the yield; and, in many cases, reduce the use of consumables; reduce harmful effects on the environment.

2. Materials and methods
Precision farming technologies comply with the industry management strategy that uses information and communication technologies on collecting data from a variety of sources to support crop production decisions [1].
There are different ways to interpret the concept of precision farming:
- an integrated system concept aimed at optimizing the production process based on the variability of the agroecosystem [2];
- a set of methods or models of application for the management and processing of a localized area in the field [3];
  - management of the variability of agriculture in order to increase economic benefits and reduce environmental impact [4];
  - consists of automation of crop management in specific areas with the use of computers, sensors and other electronic equipment [5].

These approaches agree that accurate spatial information is generated that results in increased awareness about soil conditions and soil characteristics, thus encourages more efficient farmland processes. To generate precise information, particular tools are required for collecting data, analyzing information, and various technologies are needed for visualizing and interpreting them for further decision-making. Dealing with precision farming technologies is based on specific information about the area, for which they must have an associated spatial component, that is, the data must be georeferenced. This helps to define differentiated agronomic management depending on the specific status of land resources, environment and yield. At the same time, the introduction of precision farming technologies at agricultural organizations of the Russian Federation is proceeding at a slow pace. This urges to intensify this activity by identifying and assessing the benefits and challenges, risks and development opportunities.

The study aims to identify opportunities, threats, strengths and weaknesses and develop scientific and practical recommendations on intensifying the use of precision farming technologies in agriculture.

The research objectives are:
- to analyze the main technologies of precision farming used in agriculture;
- to identify the strengths and weaknesses, to outline the opportunities and threats of using these technologies in agriculture;
- to perform a quantitative assessment of the identified strengths and weaknesses, to outline the opportunities and threats of using these technologies in agriculture;
- to develop scientific and practical recommendations on reduction the negative impact of weaknesses and threats and development of strengths and opportunities.

To identify barriers for using these technologies at agricultural organizations, a SWOT analysis will be used to determine the status and prospects of using precision farming technologies in the region. This will make it possible to identify the strengths and weaknesses, to outline the opportunities and threats for development of agriculture in the context of the application of these technologies. For assessing the identified characteristics, experts were involved, such as agricultural managers from the Sverdlovsk and Kurgan regions, as well as representatives of the academic community specializing on development of the industry (Figure 1).
As Figure 1 shows, the largest proportion of experts are men (85.1%), which is due to their predominance among the heads of agricultural organizations in the Middle Urals. The largest share is experts of 45-61 years old (55.3%); the middle age category is people of 30-44 years old (34%); a small share (10.6%) is young people aged of 18-19. The largest share in terms of educational level is specialists (55.3%) who received their education before the entry of the Russian Federation into the Bologna process for unification of educational standards, but 14.9% have a master's degree. It should be noted that all experts from the academic community (employees of universities, research institutes) involved in the research have an academic degree.

3. Results
Recently, the use of precision farming technologies has been expanded significantly due to the interdisciplinary work of researchers, technicians and manufacturers of this technology, who proposed and enriched concepts, methods and technologies based on their knowledge, research and practical experience of their use [6].

Targeted efforts on better application of precision farming technologies have become possible due to the development of technological tools that make easier collecting, managing and using the information. First of all, it deals with various types of sensors, including local or remote ones. The former can be located directly on the ground, most sensors of this type collect data by coming into direct contact with the object of study (soil, plants, environment) at very short distances. The second category of sensors are located on the ground, air or space platforms and do not contact with the object of study directly. It is important to note that in the use of precision farming technologies, there is a growing tendency towards the use of wireless technologies, which include the use of mobile systems without losing the accuracy of measurements and the quality of the collected data.

The strengths are associated with the internal components of agricultural development arising in the process of introducing precision farming technologies. The assessment by the experts is shown in Figure 2.
Figure 2. The assessment of strengths in activity on introduction of precision farming technologies, %.

As Figure 2 shows, the greatest strength in development of agriculture in the context of introduction of precision farming technologies is to increase the level of awareness of agricultural heads and specialists about the progress of work performed (39.6% of the highest assessments of experts). At the same time, another 37.5% of experts' assessments were 4 points for this position, and the conditional index was 4.13 points. It is true, as precision farming technologies make it possible to improve data collecting about the conditions of lands. Another strength of the use of these technologies is the reduction in consumption of material resources (31.3% of the highest assessments). This may be so due to the possibility of targeted and differentiated use of plant protection products, fuel, seed material and fertilizers. The conditional index of the assessment of this strength was 3.83 points. Another strength in development of agriculture in the context of introduction of precision farming technologies is anti-theft and struggling against unfair workers. This position received 33.3% of high marks (4 points by the rating scale), and the conditional index was 3.44 points. According to the experts, precision spending of consumption of inventory items, including fuel, fertilizers, seed material, with the use of precision farming technologies has reduced the unauthorized use of the organization's resources by unfair workers [7]. The agricultural production is associated with a negative impact on the environment. The use of precision farming technologies will reduce it (18.8% of the highest assessments) by means of precise spending of plant protection products, fertilizers, etc. However, this moment occupies relatively low positions (the conditional index is 3.35 points) among the other strengths of the activities of agricultural organizations. Perhaps this is due to the low level of detection of facts of violation of environmental legislation by farmers.

The opportunities are certain factors that can promote the introduction of precision farming technologies in agriculture. The assessment by experts is shown in Figure 3.
Figure 3. The assessment of opportunities in activity on introduction of precision farming technologies, %.

As Figure 3 shows, the increase in availability of the Internet at rural areas has recently made favorable opportunities for intensifying the introduction of precision farming technologies in the industry. It is associated with 27.1% of the highest ratings (5 points at the assessment scale), and the conditional index was 3.56 points. Indeed, the use of wireless technologies with sensors and other digital technologies is difficult to imagine without the World Wide Web. Another opportunity for development of the application of precision farming technologies is the interest of top managers - 20.8% of the highest ratings (the conditional index is 3.48 points). The availability of a developed network of suppliers of precision farming technologies promotes the introduction of these technologies (35.4% - assessments of 4 points and 12.5% of 5 points). This concerns both Russian suppliers and foreign ones. The increase in price availability of precision farming technology is associated with a dramatic decrease in the cost of components such as sensors and detectors. For example, from 2004 to 2014, the average cost of sensors decreased (from $1.30 to $0.60), and their cost is expected to fall by another 37% to $0.38 by 2022 [8]. However, the experts did not assess these opportunities highly - only 10.4% of them gave 5 points, and the average index was 2.9 points. Perhaps this is due to the fact that these technologies are still expensive for farmers.

The weaknesses are characteristics of agricultural development that have a negative impact on the introduction of precision farming technologies (Figure 4).
As one can see at Figure 4, the functional and physical depreciation of the material and technical base makes the most significant obstacles to the introduction of precision farming technologies. This factor is associated with 49.0% of expert assessments of 5 points, and the conditional index was 3.98 points. Another weakness of agricultural organizations is their low paying capacity. So, according to the Federal State Statistics Service, only 80% of agricultural organizations worked with a profit in 2017-2020 [9]. However, not all of them can allow the renewal of tangible assets. Another weakness is a low qualification of personnel capable of using precision farming technologies. This point was favored by 20.8% of experts' assessments, and the conditional index was 3.42 points. Finally, low awareness about possible benefits of using precision farming technologies is weakness - 10.4% of high ratings and the conditional index is 3.42 points. This may be a consequence of training at technical schools and universities according to outdated curricula. Managers and professionals do not understand the benefits of these technologies.

The threats reflect circumstances from the external environment that can harm the introduction of precision farming technologies in agriculture (Figure 5).

**Figure 4.** The assessment of weaknesses in activity on introduction of precision farming technologies, %.

![Graph showing the assessment of weaknesses in precision farming technologies](image-url)
As Figure 5 shows, the greatest value - 22.9% of expert assessments (5 points) believe that the main threat to the introduction of precision farming technologies is insufficient government support. Subsidies to agricultural organizations are an important part of public policy in all countries. However, in Russia it is lower in comparison with the countries of the European Union by 10 times per land area [10]. At the same time, the experts notice a high dependence on fluctuations in the exchange rate of currencies - the conditional index is 3.21 points. This is explained with the fact that a significant part of sensors and other components of precision farming are import. When the exchange rate changes, the price of these technologies increases and they become less affordable for farmers. A significant threat to the development of agriculture in general and the introduction of precision farming technologies in particular is a decrease in human capital at rural areas (the conditional index is 3.08 points). This reflects on general aging of the population at rural areas, a decrease in the level of education, migration outflow to cities, which does not promote conditions for development of technologies such as precision farming.

4. Discussions
According to the analysis, the experts identified the greatest concern about the internal characteristics of development of the industry, which agricultural organizations can influence during the introduction of precision farming technologies. Thus, the highest conditional index of assessments has an increase in the level of awareness of agricultural managers and specialists about the progress of work performed (the conditional index is 4.13 points). At the same time, the decrease in consumption of material resources (the conditional index is 3.83 points) is at the third place in terms of importance. The greatest concern is about the functional and physical depreciation of the material and technical base (the conditional index is 3.98 points) and insufficient government support (the conditional index is 3.44 points). This proves a significant interest of the expert group, primarily managers and specialists of agriculture, to the problems of introducing precision farming technologies.

5. Conclusion
The study identifies opportunities, threats, strengths and weaknesses in the introduction of precision farming technologies. This results in better understanding of the processes of introducing these
technologies and developing scientific and practical recommendations for intensifying the use of precision farming technologies. The use of precision farming technologies can promote the awareness of farmers about the progress of the work performed, the reduction in consumption of fuel, plant protection products, seeds and other materials. However, it is necessary to take targeted measures by the state to increase state support for updating the material and technical base of agriculture, restoring the human capital in the industry. It is necessary to make conditions for development of technologies for precision farming of domestic (Russian) production, which will reduce the dependence on fluctuations in exchange rates. The research results can be used to develop a model for increasing the competitiveness of domestic agriculture in dependence on various scenarios for the introduction of precision farming technologies.

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