Formation of a portfolio of digital technologies and solutions for the production and storage of agricultural products

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Abstract. Guaranteeing food security in the country is a multifaceted issue that requires a comprehensive solution. It is important not only to produce raw materials for food products, but also to establish an efficient logistics network that will ensure delivery to the final consumer. In order to do it, it is important to store agricultural products, livestock and fish, as well as to create a reliable material base that will ensure the safety of products throughout the entire storage period.

1 Introduction

Many economic sectors have not developed their production infrastructure in foreign markets, and there are fears of a crisis in high-growth sectors such as dairy, poultry, sugar, oil and fat industries.

In recent years, Russian agriculture has been facing problems related to the ban on the import of certain types of products, the solution of which requires the introduction of digital technologies in the industry [1].

To improve the efficiency of Russian agriculture, it is necessary to introduce the latest information technologies, such as LPWAN, BigData, artificial intelligence and control platforms, as well as to use the domestic measuring equipment, such as RFID tags, controllers, sensors and control systems.

Today, Russia's agriculture plays an important role in ensuring the country's food security and using its export potential. However, the creation of a highly developed and high-tech industry that can meet the needs of citizens and export destinations requires the introduction of innovative technologies and complex management decisions. In order to provide Russian citizens with high-quality and safe products, it is necessary to create favorable conditions for

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the development of agriculture, introduce advanced methods and technologies, and stimulate decision-making.

Today there is an urgent need to introduce digital transformation in Russian agriculture. However, the current level of digitalization raises several concerns due to the lack of knowledge about modern agricultural technologies, the instability of agricultural prices and the lack of information technology and equipment. These factors lead to high production costs and underdeveloped logistics systems. Only a few goods producers have a financial opportunities to purchase new equipment and use IT equipment. It is necessary to stimulate the introduction of digital technologies and ensure the availability of their use for all agricultural enterprises in order to achieve high efficiency and provide quality products for the country's population and exports.

2 Problem statement

In order to switch to robotic systems and digital technologies in agriculture, in recent years, research has been carried out in the field of non-invasive spectroscopy of grain crops with various types of radiation (laser IR and Raman spectroscopy). The creation of a complex of technical means for computerized electron-optical sorting of seeds will improve the process of separating seeds into crops and determining their qualitative characteristics, including varietal affiliation, biological productivity, and phytosanitary purity. These studies can significantly imp rove the process of agricultural production and increase the efficiency of resource use.

In addition, the followings are being developed:
- concepts of technology and structural construction of seed-cleaning and drying enterprises in elite seed farms;
- algorithm and program called "choose of technology for post-harvest processing of grain and seeds by grain manufacturer based on the program of cost optimization (maximum profit)";
- means for measuring and stabilizing the air flow rate in the channels of air separators of air screen machines (suitability of machines for computer control);
- initial requirements for the equipment of express laboratories of plants for post-harvest processing of grain and seeds;
- an algorithm for managing the technological process of post-harvest processing of grain and seeds based on data from an express analysis of the properties of the initial material.

3 Research questions

Purpose of research is to evaluate and give recommendations on the use of digital and other modern technologies in the field of processing and storage of various agricultural products.

The task of transformation has been outlined by the decree of the President of Russian Federation No. 204 dated May 7, 2018 "On the national goals and strategic objectives of the development of the Russian Federation for the period up to 2024".

The state shall understand that the development of the economy will also have a beneficial effect on the social sphere of society, but the development of the economy is possible only if new modern technologies are introduced into it [2,3].

4 Materials and methods

Currently, the introduction of modern technologies in the field of agriculture is carried out to achieve the following goals:

1) to develop the agriculture in general, to increase the amount of produced agricultural products (as the production base will be updated, new modern technologies will be introduced, and new ways of processing of finished products will appear);

2) there is a reform of management activities, which is implemented by authorized state bodies in the field of agriculture. In particular, they can apply only the most competent and effective solutions, which is also possible only with the help of modern technologies. Thus, public authorities are connected to a single information system, which contains significant amounts of information. The system can be used to monitor land use and track land used for agriculture. Moreover, such systems contain information about the form of ownership of a particular land plot.

The use of new information resources will allow an economic entity to use information systems in interaction with each other, and also allow communication processes with competitors, consumers and other interested parties. In addition, it shall be noted that interaction with consumers is also carried out from public authorities.

Integrated information systems created for agricultural enterprises should be built using modern technologies. A feature of such unified information systems is also that they operate on the basis of the principle of publicity, that is, anyone can get acquainted with this or that information if he or she has access to the Internet. For some persons, personal accounts are created. It shall be noted that authorized authorities create information systems only within their competence. The created information systems are necessary in order to carry out further analytical work.

5 Results

During the introduction of modern technologies in the field of agriculture, as well as the creation of special platforms, it became possible to:

1. creation of information systems that provide information on the availability of land resources, on what crops are grown on these land plots, the amount of harvest, as well as information on the equipment used, similar information is also collected if livestock is being farmed;

2. dissemination of modern technologies in the activities of the authorized bodies of the constituent entities of the Russian Federation that are responsible for agriculture, in particular, these technologies allow for planning for agriculture;

3. distribution of modern technologies to the activities of the authorized bodies of the constituent entities of the Russian Federation that have power in the field of agriculture, as a result of which it becomes possible to save natural resources, use new land plots suitable for agriculture;

4. modern technologies make it possible to reduce the cost of farming, for the implementation of product processing;

5. due to the fact that agricultural organizations cease to incur additional costs, this in turn leads to a decrease in the cost of products;

6. the efficiency of labor activity of employees increases;

7. agricultural entities are becoming more interested in digital technologies and are actively implementing them in their activities, while attracting investments from other stakeholders;

8. the implementation of effective production activities is impossible without taking into account advanced scientific developments;

9. Achieving a sustainable increase in the material well-being of rural residents is an important task that requires an integrated approach [4, 5].

To achieve this goal, it is necessary to solve the following tasks:

1. For the goal of "Digitalization of agricultural production":

• for the successful digitalization of agriculture, it is critical to identify the highest priority technologies that will be used at all stages of production;

• for effective digitalization of agriculture, it is important to have highly qualified specialists who are ready to apply digital technologies in practice;

• it is necessary to develop computer-aided design systems in order to create automated workstations (AWS) and form groups of practical services. These services include cloud-based solutions to help optimize and establish crop patterns, fertilize, tillage, integrate plant protection, seed production, soil erosion protection, and environmental protection in agriculture;

• to improve the efficiency of agricultural production, it is necessary to introduce digital tools such as information resources, platforms and technologies;

• develop and implement advanced digital solutions, including technical tools and automated systems, to increase the level of intelligent robotization in agriculture;

• apply financial and regulatory mechanisms to reduce fluctuations in prices for seasonal agricultural goods and use information tools to effectively manage stocks of goods in exchange warehouses (for example grain, oil, sugar, milk powder);

• To improve the efficiency of interaction between producers of goods and public authorities, it is necessary to digitize information flows and integrate access to various information resources. To achieve this goal, such technologies as decentralized cash registers, electronic warehouse documents, acts of receiving goods for processing and transaction support can be introduced. It ensures that any authorized user, regardless of their number, can easily and quickly access the information that they need [6,7];

• to improve the effectiveness of training and advisory services in agriculture, it is necessary to create a modern digital environment for the development of distance education in agriculture and the market for professional agricultural consulting, using advanced technologies, platforms and tools;

• to develop and implement programs and projects to train IT competencies in agriculture, as well as create conditions for attracting talented and qualified specialists to the agricultural industry, offering them high levels of wages and career prospects.

The goals of digitalization of management activities in the field of agriculture shall also be considered.

1. In particular, each producer of agricultural products must have a personal account, which he can enter using the Internet. The possibility of personal accounts lies in the fact that they allow them to obtain the information they need, in particular on the legal regulation of agricultural activities, on how the state stimulates the activities of business entities.

2. Maintaining various accountings, the object of which are land plots intended for agriculture, while it is possible to maintain several records at the same time, in this case it is necessary that they be combined into the Unified Federal Information System on Agricultural Land (UFIS ACL), which will allow to receive information on the total amount of land that can be used for agriculture. Also using these registers, it is possible to get the information about the condition of these lands, the suitability of their use in agriculture. In the same way it is also possible to get information about the cadastral value of an individual land plot and about its location [6].

3. Create and implement methodological recommendations for assessing the value of a land plot in the activities of authorized entities, as well as create and provide agricultural producers with methodological recommendations for business development.

4. The use of modern digital technologies in the field of agriculture will make it possible to use land effectively, including for the development of municipalities, within which these land resources are located. They also allow to assess the possibility of use of the land plot in the field of agriculture.

In this case, the quality of the soil on the land plot is analyzed, it is determined whether there is a need to carry out drainage on the territory of land plots that are intended for agriculture, while such actions can be carried out by both business entities and individuals who are independently engaged in agriculture.

5. The introduction of a digital platform into the activities of the authorized bodies, which will allow for effective control measures, within which it is possible to identify the misuse of land resources, as a result of which the latter will be subsequently withdrawn from possession, and also if such use causes significant damage to the land plot, a negative impact on natural systems is carried out.

6. Introduce such digital technologies that allow to analyze the state of the agro-industrial market constantly, while these digital technologies shall be used by authorized state bodies.

7. Form the tools with which it will be possible to influence the agricultural policy of the regions.

8. Disseminate technologies that can provide an interested person with information about obtaining preferential loans that are allocated by the state as a measure to support agriculture, and can also provide information about agricultural production insurance.

9. Creation of a legal framework that will fully regulate the process of creating and implementing modern technologies in the agro-industrial complex.

6 Findings

There are various directions for the development of digitalization, including:

1. it is necessary to strengthen measures of state support for producers, develop an appropriate regulatory framework for the successful implementation of digital technologies, improve the financial and insurance sectors, develop infrastructure for the safe and efficient storage and processing of agricultural products, optimize the supply chain;

2. it is necessary to further develop the information infrastructure in rural areas with an emphasis on reliable information security;

3. capacity building is needed to improve research and technical skills;

Agriculture uses various tools for digital transformation:

1) Development of a set of processes and methods of digitalization in agriculture, taking into account economic and resource factors, aimed at increasing the profitability and efficiency of agricultural production at all stages from production to sale, using the latest digital technologies [7];

2) Creation of a new platforms for producers called "Efficient Hectare" and "Efficient Head" which will allow to form a dynamic seasonal KPIs for agricultural production. It is an innovative approach that will allow agricultural producers to use their resources in the most optimal way;

3) Conditions for the operational use of Russian differential positioning devices in digital systems and precision farming systems operating with GLONASS / GNSS signals shall be created [6];

4) One of the key elements of increasing the agricultural production is the creation of a platform for objective monitoring and management of transport and logistics infrastructure;

5) Creation of databases on agricultural machinery, machinery and equipment, soil properties, crops and varieties, fertilizers and pesticides, diseases and pests, economic models, etc. plays an important role in the success of the agricultural business;

6) Development of methodologies, algorithms and management methods is an important step towards the introduction of "digital agricultural enterprises";

7) Adaptive land mapping and economic modeling in agriculture require the development of methods and algorithms for predicting the state of agroecosystems;

8) Creation of an automated system for design of agricultural land, taking into account their optimal use and protection, is an important step in the development of the agricultural sector;

9) Development of a set of processes and methods of digitalization in agriculture, taking into account economic and resource factors, aimed at increasing the profitability and efficiency of agricultural production at all stages from production to sale, using the latest digital technologies;

10) Development of innovative technologies and software products that provide producers with information on technical and economic aspects is a key factor for optimization of agricultural production;

11) Creation of a new type of farms (innovative farms) which can serve not only as platforms for the development of new technologies, but also as centers of learning and knowledge transfer;

12) The use of IoT platforms in agriculture is an important step in its development, as it allows to carry out the digital management of agricultural machinery, greenhouses, equipment and material flows. This improves energy efficiency and simplifies traceability management;

13) It is necessary to ensure compliance with international standards and industry protocols in order to reduce dependence on imports and increase the share of domestic technologies in agriculture;

14) Telemetry data monitoring is becoming increasingly important;

15) Digital dashboard is currently being developed to be used as a data center containing information about the land;

16) Efficient use of resources in agriculture can be achieved through the use of digital tools for studying the structure, composition and condition of the soil, crop control, yield analysis and pest monitoring;

17) Technical performance of the precision farming system and the use of local materials are very important. The system is based on a digital map of soil properties and pesticides, which provides information on soil structure and fertility in each field at a scale of 1:10,000. The system also allows to carry out more efficient use of resources and provides reduced environmental impact while using fertilizers and pesticides;

18) Introduction of modern technologies in such an agricultural sector as livestock, as a result of which it is possible to track the life cycle of animals, which in its turn leads to an improvement in the quality of products in this industry, as well as an increase in the sale of the resulting products;

19) Establishment of a unified procedure for the exchange of information between various state authorities that exercise their powers in the field of agriculture;

20) Use of modern technologies in the creation of new varieties of agricultural plants, animal breeds, the creation of new varieties and breeds is a very important activity, as they will be distinguished by increased adaptability, including to harsh climate conditions, as a result of the intervention of science, new varieties and breeds can bring much higher yields, not be subject to disease. As a rule, modern technologies in genetics are used in breeding centers [5,7];

21) It is especially important that digital technologies be used in the course of training future specialists who study at an educational institution of higher and secondary vocational education, as a result of which specialists, having received new knowledge, will be able to apply them in practice in their professional activities. In addition, they are also used in the retraining of agricultural specialists;

22) Modern technologies can be used to control the production of products at all technological stages;

23) Digital technologies can be used to create single platforms on which agricultural products will be traded and purchased, which will allow economic entities to sell their products.

Modern technologies in the agro-industrial complex can be used to improve logistics processes, resulting in improved interaction between consumers and entities that sell these products, while, as a rule, such entities carry out retail trade. Consequently, digital technologies also affect the management process in the circulation of agricultural products [7].

7 Discussion

According to the Ministry of Agriculture of Russia and experts, the use of digital technologies in the agro-industrial complex (AIC) will significantly increase the profitability of agricultural production due to more accurate cost optimization and efficient capital allocation due to an integrated approach to the implementation of the digital economy. This is expected to reduce costs by at least a quarter. Meanwhile, according to Rosstat, spending on ICT in agriculture in 2015 amounted to 4 billion rubles, which is 0.34% of investments in ICT in all sectors of agriculture, and in 2017 - 0.85 billion rubles (0. 2%) [1].

The low level of digitalization in agriculture indicates a significant potential for the introduction of information and communication technologies and investments in this area. Therefore, the agricultural sector has the opportunity to become one of the most promising objects for the implementation of digital solutions and increasing production efficiency. In modern scientific literature, scientists discuss several directions for the introduction of digital technologies in the agro-industrial complex. It is important that modern technologies that are used in agriculture are also applied in the regions of Russia.

In particular, such digital systems as Digital Land Use, Smart Field, Smart Garden, Smart Greenhouse are currently the most relevant, while it is important to note that all these systems are based on modern Russian technologies [8].

Today digital management systems, such as "Digital Land Use", "Smart Field", "Smart Garden" and "Smart Greenhouse" are the most relevant in agriculture. It is important to note that all these systems are based on modern Russian technologies, which demonstrates the high potential of Russia in the development of digital solutions for agriculture. It shall be noted that modern technologies are also being actively introduced into the dairy industry: first of all, they are used in the cultivation of agricultural products, which will later be used as feed, digital technologies allow, for example, to determine when it will be possible to harvest, what kind of crop it will be. will be, new technologies can also help remotely obtain information, for example, using drones [10,11,13,14].

In addition, business entities in the dairy industry are actively using modern technologies such as cloud storage, as they allow you to collect all the necessary information and store it in the proper order, while employees of the business entity can receive this information at any time.

Digital technologies are also used to control the production process, namely, the condition of seeds and fertilizers is determined, in particular, such control is possible using special mobile applications [9].

Only innovation-oriented companies are able to ensure the rapid implementation of these areas.

It shall be noted that food enterprises in their activities, including production, use modern technologies.

In this direction, the following measures shall be taken:

1. introduce robotic technology that can process industrial waste, including food. In particular, in this case, robots can search for suitable waste and then move it to another location;

2. augmented reality. This direction is quite relevant at the present time, since augmented reality makes it possible to prevent equipment from stopping, as well as to control the progress of production activities, even if a person is far away;

3. machine vision. It allows to control how the technical equipment performs its activities. Also, machine vision allows you to analyze information about how the production process is going on and how employees perform their job duties. In this case, the analysis is carried out at the moment when the production of goods began. Machine vision allows to determine the quality of raw materials, the quality of the final product. Modern technologies also make it possible to determine the health status of employees, whether they comply with safety rules at the facility;

4. the use of artificial intelligence in the activities of a food enterprise allows to establish and control the process of transporting products, as well as improve production activities. Artificial intelligence can identify the reasons for a stoppage in production, and then independently eliminate these reasons;

5. in addition, it is advisable to use systems that allow you to analyze various information about the state of affairs on the market, for example, about how products are sold on the market, how an individual product is sold. It shall be noted that information is collected by these systems automatically and can analyze sufficient amounts of information. It shall be noted that quite often several modern technologies are used at once, which will improve the efficiency of an economic entity [12,15,16,17,18]. Some technologies that are used in the course of the activities of an economic entity will allow them to ensure information security, as well as the security of the economic entity itself;

6. smart packaging shall be used to provide consumers with all the necessary information about the products. It is worth noting that the consumer can also get the information they need by installing a special mobile application. In particular, in this way you can learn about how products are processed, where raw materials are grown, and also which company produced the final product. In this case, it is also possible to use augmented technology, that is, the consumer will be able to see how the product looks from afar;

7. use of machine evaluation systems. Such systems make it possible to determine the quality of manufactured products using technical devices, first of all, products that do not meet the established requirements are identified. Such systems determine the suitability of products for consumption, as well as monitor the storage conditions of products and raw materials used by the food enterprise;

8. RFID is an automated object identification system that continuously tracks the movement of goods in and out of production facilities, allowing industrial companies to optimize their production and logistics processes, from inventory planning to full traceability to the final consumer;

9. The production of food products with a taste similar to other food categories, such as virtual food, is growing rapidly. As the number of vegetarians increases, so does the demand for meat-like products. At the same time, important breakthroughs were made in the development of animal-free artificial protein synthesis;

10. 3D product printing is an innovative technology that allows to make products by order in accordance with the specified parameters. Some models are also equipped with scanners for more accurate product reproduction. However, the use of digital and innovative technologies in the food industry requires special attention to the information security of all production processes. IoT technology is widely used to maximize production efficiency and safety.

International experience clearly demonstrates the significant benefits that can be brought by the use of digital technologies (Table 1).

Table 1. Examples of the use of innovative technologies in the food industry.

Country	Technology	Application Benefits
China	Cameras with artificial intelligence to monitor the implementation of production technology in catering	Prevention of violations of sanitary standards, ensuring the safety of production and the quality of finished products
Great Britain	Sensor technology for cleaning food processing equipment based on artificial intelligence	Optimization of the cleaning process in terms of time and order, saving water and energy, reducing equipment downtime
Norway	Machine learning in fruit and vegetable sorting	Release of labor force in sorting processes, work accuracy, rejection prevention
USA	Startam Wi - Next - software for the operation of sensors on a bottled water production line	Ensuring the smooth operation of production lines with high speed, fulfilling the accuracy of filling each bottle when bottling water
Chile	NotCo platform - machine learning in the development of milk and meat substitutes	Derivation of a set of ideal substitutes for given parameters and nutritional properties
Germany	IoT – air ammonia level sensors at Langnese ice cream factory	Ensuring the safety of employees when working with liquid ammonia

Source: [15].

8 Conclusion

The latest technologies based on safe storage methods and means can be used to increase the longevity of food.

Innovative approaches and tools for food preservation have been developed in Russia. These approaches have successfully passed practical tests in the country and abroad. However, their widespread use in food storage organizations remains unsatisfactory due to a variety of factors. With the change in consumer features of food products on the market, the features of raw materials, recipes and production technologies are constantly changing, so the introduction of new technologies have become very important.

In order to preserve the quality of food, it is necessary to develop special preservation methods that take into account new and changing features of products. Innovative food preservation methods include climate control, proper storage layout, and different storage methods based on expected shelf life. For example, to extend the shelf life of semi-smoked sausages, it is necessary to store them at the optimal temperature of from -3 to -5 C and at a relative humidity of 85-88%, and also treat the chambers and products with ozone at a concentration of 3-5 mg/m3. However, despite the development of innovative technologies, their widespread use in food storage organizations is limited by objective and subjective reasons.

There are several categories of storage methods and tools that are used to store various goods:
– techniques for managing the features of the climatic situation in the process of conservation;
– goods in stock are taken into account by various indicators: load factor, height and density of goods in packaging or without it;

– procedures and tools used to process goods before they are placed in a warehouse or during their storage (it is a set of methods and tools aimed at maintaining product quality).

Innovative technologies for the storage of different food groups use different methods and means in accordance with the natural preservation of each product. If the product has a high degree of preservation from the very beginning, fewer methods and means of care are required. For example, cereals are highly preserved due to their low moisture content and unique structure. Therefore, maintaining optimal relative humidity and active aeration are essential for grain preservation technologies. This allows to maintain the quality of the grain and extend its shelf life, which is an important factor for agricultural enterprises and other companies involved in the production and storage of grain crops.

References

1. "Digital Economy of the Russian Federation" program (approved by the order of the Government of the Russian Federation No. 1632-r dated July 28, 2017

2. Decree of the President of the Russian Federation dated May 7, 2018 "On national goals and strategic objectives for the development of the Russian Federation for the period up to 2024"

3. Decree of the Government of the Russian Federation No. 1455 dated 07.07.2017 "Strategy for the development of agricultural engineering in Russia for the period up to 2030"

4. Order of the Ministry of Agriculture of the Russian Federation No. 3 dated January 12, 2017 "On approval of the Forecast of scientific and technological development of the agro-industrial complex of the Russian Federation for the period up to 2030"

5. "Forecast of scientific and technological development of the Russian Federation for the period up to 2030" (approved by the Government of the Russian Federation on July 10, 2018).

6. Federal Law No. 101-FZ dated July 24, 2002) "On the Turnover of Agricultural Land"

7. E. V. Truflyak, A. S. Kramer, N. Yu. Kurchenko, *The results of the survey in the direction of "Digital agriculture"* (Kuban State Agrarian University, Krasnodar, 2018)

8. *Digital transformation of Russian agriculture* (FGBNU "Rosinformagrotech", Moscow, 2019)

9. V. F. Semenikhina, I. V. Rozhkova, A. V. Begunova, T. A. Luxurious, T. I. Shirshova, Dairy industry **10**, 60-61 (2017)

10. G. Ya. Rezgo, M. A. Nikolaeva, Food industry **4** (2010)

11. Industrial production. Federal State Statistics Service of the Russian Federation, https://rosstat.gov.ru/enterprise_industrial

12. TOP 10 digital technologies for the food industry and ensuring the information security of the enterprise infrastructure, https://www.comnews.ru

13. E. V. Dudukalov, V. D. Munister, A. L. Zolkin, A. N. Losev, A. V. Knishov, Journal of Physics: Conference Series **1889(5)**, 052011 (2021)

14. A. L. Zolkin, E. V. Matvienko, M. V. Shavanov, "Perspectives for the use of digital technologies in the agricultural sector in order to optimize agricultural

operational processes", in *IOP Conference Series: Earth and Environmental Science. International science and technology conference "Earth science"* (2021), 032081

15. Yu. B.Gerber, "Fundamental problems of storage and processing of agricultural products, directions, techniques and methods for their solution", in *Agrobiological foundations of adaptive landscape management of agricultural production. Collection of abstracts of reports of the participants of the Russian theoretical and scientific-practical, anniversary conference dedicated to the 100th anniversary of the establishment of the Academy of Bioresources and Nature Management (2018)*, pp. 154-157

16. A. A. Chekushov, M. A. Chirkov, M. S. Chistyakov, Management and business administration **3**, 69-80 (2019)

17. N. V. Zakharchenko, S. L. Hasanov, A. V. Yumashev, O. I. Admakin, S. A. Lintser, M. I. Antipina, Journal of Environmental Management and Tourism **9(3)**, 510-523 (2018)

18. V. Zhukovskyy, S. Shatnyi, N. Zhukovska, J. Perhac, "Information System of Cartographic Images Analysis for Soil Condition Monitoring of Agricultural Parcels", in *2022 International Conference on Decision Aid Sciences and Applications (DASA)* (Chiangrai, 2022), pp. 1640–1644