System modernization of agriculture under digitalization conditions

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Abstract. The article reveals the main trends in the development of agriculture and the agro-industrial sector of the economy as a whole, the existing problems in the use of digital technologies and automated agrotechnical solutions. The subject of the study is the agricultural industry functioning under the conditions of new technological and economic challenges. The purpose of the study is to form conceptual ideas about the prospects of using digital solutions to ensure sustainable development of agriculture in the conditions of global technological changes and actualization of the ESG agenda. Key factors and conditions of digital and ESG transformation of agriculture are identified. The current directions of systemic modernization of the industry are identified. It is shown that digitalization and modernization allow to develop the practice of sustainable development of agriculture and agro-industrial complex as a whole.

1 Introduction

Agriculture is one of the most important sectors of the Russian economy. The annual output of agricultural products exceeds 100 billion dollars. The role of the agricultural sector of the economy is not only to provide the country's population with agricultural products, but also to stimulate the development of other industries: machine building, processing industry, transportation industry and others. The agro-industrial sector of the Russian Federation is growing and developing at a good pace, reaching a new quality of development in the conditions of digitalization. At the end of 2023, agro-industrial export revenues amounted to $43.5 billion, 147 million tons of grain were harvested. Russian agricultural products are sent to 150 countries of the world, despite all the difficulties and restrictions associated with the sanctions of Western countries. The volume and quality of application of modern technologies, including data collection, storage and processing systems, are increasing in the agro-industrial complex (Fig. 1).

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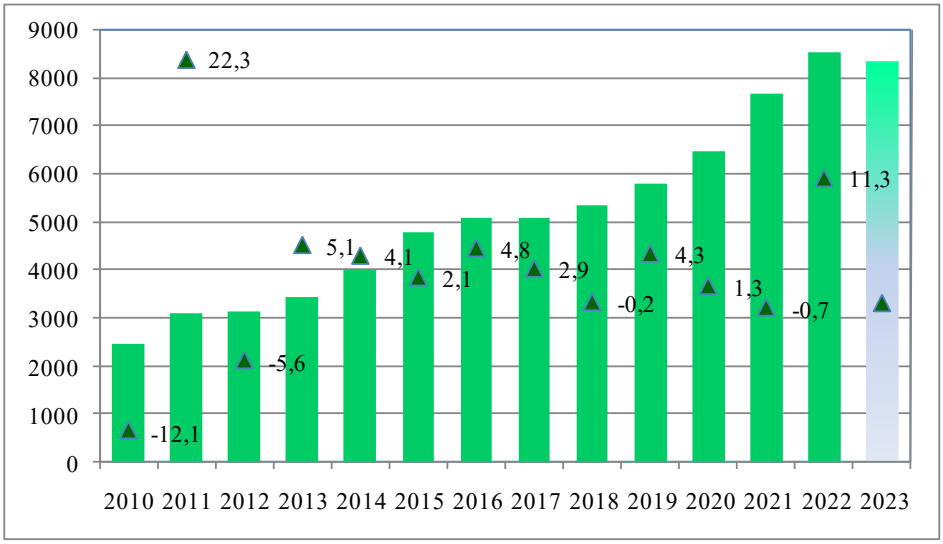

Fig. 1. Dynamics of agricultural production in the Russian Federation, bln. rub.

In 2023, the Government of the Russian Federation approved a document aimed at the digital transformation of the agro-industrial complex in Russia [1]. The document outlines promising areas and directions of application of digital technologies in the agro-industrial complex. It is expected that the introduction of digital products will make it possible to streamline business processes at agricultural enterprises, increase the transparency of agribusiness and ensure the efficiency of management decision-making. Currently, there are many unresolved problems in rural areas and in the agricultural industry, the number of agricultural organizations is decreasing, and the standard of living of the rural population differs significantly from the urban population.

The purpose of the research is to form conceptual ideas about approaches to ensure sustainable development of agriculture in the conditions of digital and ESG-transformation, new technological and economic challenges, changes in the conditions of agribusiness.

In response to digitalization challenges and current demands of society, the Russian agribusiness sector is becoming more and more clearly oriented towards the introduction of technological innovations and ESG-principles, which in the future will provide it with real competitive advantages. However, in order to successfully implement digital technologies and sustainable development principles in the industry, it is necessary to take into account not only technical and technological aspects, but also socio-cultural characteristics of the rural population, which cause certain barriers to organizational and technological changes. Involvement of agricultural personnel in transformation processes, ensuring cybersecurity and green investments, as well as continuous updating of the sustainable development strategy of rural areas taking into account the dynamically changing digital environment are the key factors and conditions for successful digital and ESG-transformation of agriculture.

2 Materials and methods

There is a large number of scientific works devoted to theoretical and applied aspects of sustainable development [2], digitalization of the economy and its specific sectors [3], as well as research that reveals the problems of development of agriculture and agro-industrial complex [4, 5]. Various aspects of sustainable development are considered in the works of foreign authors, such as K. Bolton, K. Brooks, R. Bampton, R.S. Kim, B.V. Sandvidi, R.

Sassen, A. Halabi, I. Hardek, P. Chollet and others. The works of domestic and foreign scientists consider various aspects of agricultural development, including under conditions of uncertainty and risks, as well as the issues of food import substitution and sustainable development of agricultural production [6, 7].

The conceptual basis of the research is the systemic economic theory, provisions of the theory of public administration and change, which together make it possible to study an important scientific and applied problem of formation of new approaches to ensuring sustainability and balance of agriculture in the conditions of digitalization and implementation of ESG-agenda.

Methods of systemic data analysis, methods of descriptive and comparative analysis were used as methodological tools of research in the work.

3 Results and discussion

Agriculture is the main link of the agro-industrial complex, which provides more than half of all agricultural production and concentrates about 70% of its main production assets. The development of agriculture in recent years, despite the imposed sanctions, demonstrates high production indicators. This is due to the gradual adaptation of the industry to sanctions shocks, the persistent search for drivers of sustainable economic development of the agro-industrial sector, as well as the growing demand for "green" and "ethical products" (produced by companies that comply with ESG principles), increasing the attractiveness of the industry for ESG investors. According to the forecasts of the global food market development, by 2050, due to the increase in the global population and the growth of food consumption, there will be a natural increase in the consumption of agricultural products [2]. At the same time, our country has the highest potential for increasing the area of arable land required for food production, so taking into account these trends and changes taking place, the introduction of new agricultural production technologies is the most important objective [11].

At the end of 2020, the National Technology Initiative (NTI) approved the concept of the FoodNet market development, which aims to form a globally competitive Russian "agri-food industry 4.0", i.e., to offer new production, logistics and sales solutions based on digitalization, customization of products and services, biotechnology and resource efficiency [12]. According to the document, the main segments of the Foodnet market, such as organic agriculture, smart supply chains, personalized nutrition, etc., should be actively developed, modernized, targeted investments should be directed there, and constant monitoring of changes should be carried out, as the rapidly changing environment and high risks can be barriers to positive changes in the agricultural industry.

Agriculture in the Russian Federation is developing in a high-risk environment due to a strong dependence on weather conditions and natural phenomena, a shortage of qualified labor resources, and a lack of ESG competencies among agricultural enterprises. The production process in agriculture cannot take place without proper provision of the industry with means of production, feed, seeds, plant protection products, as well as without the use of digital solutions in operational and project activities [3].

Dependence on suppliers of breeding, genetic materials and equipment, lack of storage capacity which affects the growth of production costs and profitability (Table 1), has a negative impact on the development of agriculture in the Russian Federation.

- Lack of access to global technologies hinders the development of the industry. The problem of labor shortage in rural areas is also aggravating.
- At the end of 2021, the Ministry of Agriculture of the Russian Federation developed a program of digitalization and technological modernization of the agro-industrial complex of the Russian Federation until 2030. The program provides for the use of

artificial intelligence, the Internet of Things, drones, etc. in the industry. It is also planned to develop an online platform to promote Russian agricultural products [2].

- Currently, due to the need to adapt the agro-industrial complex to the changed market conditions, to the requirements and realities of the new technological revolution, there is a need to analyze the strategic factors of sustainable development of domestic agriculture. For instance, important, in our opinion, is the issue of ensuring the conditions for strategic sustainability of the industry. The question of the drivers of strategic sustainability of Russia's agro-industrial complex is not methodologically elaborated. From our point of view, such drivers, creating the foundation of economic stability of the agro-industrial complex in all its sectors, are the system balance and proportionality of the main spheres of the agricultural industry.
- The main elements of strategic stability of domestic agriculture are:
- large-scale production, which accounts for the majority of the industry's turnover;
- technological renewal and modernization of agricultural productions;
- development of agricultural production in medium and small farms;
- implementation of ESG projects in agriculture;
- active state support for the development of the industry, measures for systemic modernization of agricultural production facilities.

Table 1. Level of self-sufficiency of the Russian Federation with seeds of domestic selection (Source: Order of the Government of the Russian Federation from 23.12.2022 N 4133-r "On approval of the list of main agricultural crops and annual planned values of the level of self-sufficiency of the country with seeds of domestic selection for each of such crops (until 2030), as well as the list of main types of farm animals and annual planned values of the level of self-sufficiency of the country with breeding products (material) of domestic production for each of such types until 2030).

Agricultural crop	Self-sufficiency level (%)								
Winter wheat	92	92.5	93	93.5	94	95	95	95	95
Spring wheat	74.3	77.5	78	78.5	79	79.5	80	81	82
Rice	92.7	95	95	95	95	95	95	95	95
Grain legumes	36.3	45	46	48	50	55	60	70	75
Oats	79.9	81.5	82	82.5	83	83.5	84	85	85
Spring barley	70.3	71	72	75	76	77	78	79	80
Soybeans	43.5	48	50	52	54	60	65	70	75
Spring rapeseed	30.6	31	32	33	40	50	60	70	75
Sunflower	23	25	30	50	55	60	65	70	75
Corn	41.8	45	48	50	55	60	65	70	77
Potatoes	6.7	9	10	11	12	13	14	15	50
Sugar beet	1.8	2.5	3	4	6	9	11	15	50

Thus, the strategic sustainability of agro-industrial complex means the systemic coordination and balance of all its subsystems, which is achieved by the proportionality of its structural components and is a necessary condition for the successful functioning of the economic system in the strategic perspective [5]. Achieving the balance of agro-industrial complex as a meso-level system can be ensured by the successful interaction of organizational and economic systems belonging to four basic types (object, process, environment, project) that form the system structure of the industry. Since the systems of each type fully function only if they interact with the systems of all other types, for successful

work, strategically sustainable development of domestic agriculture should be maintained a balanced state of its system structure.

To ensure the strategic sustainability of the agro-industrial complex, it is necessary, in our opinion, to shift the emphasis towards a systemic economic policy of territorial and sectoral development, application of SO-strategy (Strengths-Opportunities), which determines the directions of using the strengths of the domestic agro-industrial complex in the implementation of all its possibilities, including mechanisms of systemic balance of the industry, adaptation of agricultural enterprises to external and internal challenges, including digitalization of agricultural production, stimulation of innovation and technological activity

In this paper the problems of systemic modernization of the agricultural industry are considered in order to ensure its sustainable development and adaptation to the new conditions in which the Russian agro-industrial complex has to operate.

The Government of the Russian Federation in 2022 allocated 907 million rubles for the introduction of digital technologies in the agro-industrial complex of Russia (Order of the Government of the Russian Federation No. 1403-r of June 2, 2022). The volume and quality of application of modern technologies, including data collection, storage and processing systems, are increasing in the agro-industrial complex. Data from satellites, sensors, and operating systems are used. At the same time, both the volume of data and the need for their high-quality processing and reliable conclusions that can be relied on when making decisions are increasing.

Digital technologies play an important role in the development of agricultural production, as it makes it possible to optimize production processes and resources used, increase crop yields, reduce costs and negative environmental impact. Currently in agriculture, drones and unmanned aerial vehicles are widely used to monitor fields, spray fertilizers, etc.; blockchain technologies aimed at creating transparent and secure accounting systems and other technologies. According to expert estimates, subject to mass introduction, artificial intelligence can provide an increase in gross value added by 2025 by 25% in crop production and 13% in livestock farming.

However, the industry faces huge challenges and has to constantly overcome obstacles to sustainable development. The main problems of domestic agriculture are:

- land degradation and withdrawal of large areas from agricultural turnover. The share of land suitable for growing crops is about 13%. Of these, 7% are characterized by high fertility. The rest of the land is subject to overwatering, erosion, drought or waterlogging. Practically 60% of arable land and about 90% of land allocated for pastures need protection from negative natural factors [6]

- low rates of technical modernization of the industry. Despite the fact that the degree of depreciation of fixed assets in the Russian Federation decreased from 46.6% in 2018 to 40.5% in 2023 [7], in agriculture, forestry, hunting, fishing the degree of depreciation from 2018 to 2023 increased from 38.2% to 45.8 [16] and exceeds this indicator compared to the average for the economy as a whole.

- underdeveloped social sphere in rural areas, which is manifested in the difficult access of the rural population to medical, banking, educational services, in a significant income gap between the rural and urban population, migration of the population from rural to urban areas, etc. All this leads to the deterioration of demographic indicators of rural areas. According to experts' estimates, the difference between the level of labor remuneration in rural and urban areas is 60%.
- low level of market infrastructure development in rural areas. Poor roads, communication problems in rural areas, limited access to markets for financial, investment and information resources. Gasification of rural areas lags far behind the need for it.

- financial instability of the industry. The investment attractiveness of the agricultural sector is significantly lower than that of other economy levels due to the high level of risks.
- reduction in the number of labor resources in the industry. Over the past 5 years, the average number of agricultural workers decreased by 244.2 thousand people, which amounted to more than 19% in the industry (according to the Ministry of Agriculture of the Russian Federation), while in the economy as a whole this reduction amounted to 2.4% [12]. The agribusiness feels especially acute shortage of qualified specialists. In Russia there is about one IT-specialist per 1000 people employed in agriculture, and in total in the agricultural sector there are about 112.9 thousand or 2.4% of the total population employed in agriculture.
- reduction in the number of specific types of farm animals. In Russia at the end of 2023, the number of cattle in farms of all agricultural producers decreased by 1.7% compared to the end of 2022 and amounted to 17.4 million heads. Also, the number of sheep and goats decreased by 1.7%, which at the end of November in the country amounted to 20.8 million heads. In addition, there is a slight decrease in the number of poultry in agricultural organizations - by 0.5% over the year [2].
- the industry lags behind in terms of digitalization. According to statistics, about 70% of initiators of digital transformation of agribusiness do not achieve the planned results, and most of the funds allocated for this purpose are wasted.

With the high speed of change, an ESG approach is becoming increasingly topical in sustainable development management. This approach means that enterprises prioritize investment projects and management approaches based on the principles of environmental friendliness, social responsibility and quality corporate management [2]. The ESG concept has emerged as the main trend for the coming years. However, unfavorable geopolitical conditions, lack of investment - all this causes the emergence of new obstacles for the implementation of ESG-projects in the agro-industrial complex. In addition, the agricultural industry is not yet oriented to the wide application of ESG principles. The analysis shows that ESG principles are close to the principles of sustainable development and therefore they can be integrated into the development management strategies of agricultural enterprises and the industry as a whole.

The main constraints for sustainable development of the agricultural industry and implementation of ESG-principles in rural areas are the following:

- high risks of non-recovery of investments in sustainable development of agribusiness;
- lack of unified standards for assessing ESG-efficiency of agribusiness entities;
- high costs of ESG-projects realization;
- lack of competencies in ESG and sustainable development of rural areas [9].

Meanwhile, following ESG standards can make it possible for agricultural enterprises to form a positive image by participating in “green” projects, and the use of modern environmentally friendly technologies will contribute to the achievement of the necessary results and financial indicators. In addition, following ESG-principles can increase the investment attractiveness of agribusiness enterprises, as ESG-investment is now actively developing. Currently, about 40% of large investors take ESG factors into account when making decisions on investing in certain facilities or projects.

Sustainable development factors such as development of the social sphere in rural areas, improvement of conditions and labor remuneration, elimination of the digital divide, development of the economic base and attraction of business structures can lead to increased attractiveness of work in rural areas for highly qualified specialists. But this requires a change in the approach to the management of rural areas towards the use of ESG principles in combination with digital transformation. This will make it possible to increase the

attractiveness of rural areas for business, attract young people and qualified specialists to work in agricultural organizations.

Thus, the solution to the problem of sustainable development of agriculture and the agrarian sector of the economy as a whole lies in the wider use of digital technologies in agriculture, improvement of rural development management, coordination of strategies and plans for sectoral and territorial development at all management levels, implementation of modernization programs for the leading branches of agriculture. An important prerequisite for sustainable development of the industry is also the state support of agribusiness entities involved in ESG-transformation programs and development of organic agriculture. According to experts, the market of organically produced products in the Russian Federation grows by an average of 4% - 5% annually. However, in the global market of organically produced products the share of Russia is less than 1%, which indicates a huge potential for the development of this area [6].

4 Discussion

Western sanctions, as it has become evident, have become a trigger for large-scale changes in the agricultural sector, affecting the sustainable development agenda and necessitating both operational measures aimed at maintaining the functioning of the agricultural sector and a science-based strategy for sustainable development of the agro-industrial complex, which will make it possible, based on the assessment of new challenges, analysis of current trends and prospects for investment growth, to form a vector of sustainable development of agriculture, aimed at ensuring the sustainable development of the agricultural sector in the future and ensuring the sustainable development of the agricultural sector in the future

At present, large agribusinesses are undergoing a parallel digital and ESG transformation, which contributes to their sustainable development and implies a more environmentally friendly attitude, social responsibility and effective corporate governance. Small agricultural enterprises have not yet even started to adopt ESG principles and do not have information about the benefits of their use. According to surveys, only about 30% of managers of small agricultural enterprises have heard about ESG-approach, but they lack funds and time to deal with environmental issues, social development, and management innovations.

Meanwhile, sustainable functioning and development of the domestic agricultural industry is ensured by an optimal combination of ESG factors, indicating the use of modern environmentally friendly technologies, ensuring social justice, using effective management. That is, the transition to sustainable development of the Russian agricultural industry is associated with the need for infrastructural, digital and ESG transformation of the agro-industrial complex, the development of organic agriculture aimed at minimizing or abandoning synthetic fertilizers, chemical plant protection products, etc. The transition to sustainable development of the Russian agricultural industry is associated with the need for infrastructure, digital and ESG transformation of the agro-industrial complex.

The application of digital technologies in agriculture helps to improve the sustainability of production, increase yields and reduce the negative impact on the environment, making agriculture more productive and sustainable.

The analysis made it possible to conclude the relevance of systemic modernization of agricultural production and the formation of a strategy for sustainable development of the agro-industrial sector in the conditions of digital and ESG-transformation. This will make it possible, based on the balance of all subsystems of the agro-industrial complex and the integration of sustainable development issues into all areas of corporate and sectoral management, to ensure the growth of performance and competitiveness of agribusiness enterprises, their structural and financial adaptation to new challenges and threats.

As for the systemic modernization of the agricultural industry, it should be carried out within the framework of a specially developed strategy with the use of modern technologies of strategy and scenario forecasting. At the same time, the strategic goals of agricultural development and the means to achieve them should be linked and coordinated with the necessary resources, and the degree of achievement of these goals should correspond to the criteria for their achievement. As part of the strategy, it is reasonable to develop a whole package of long-term programs aimed at improving the sustainability of development of specific sub-sectors of agriculture. In order to change the strategy of systemic modernization of agriculture into a package of strategic programs and control the achievement of their goals, a set of indicators and indicators of sustainable development of specific sub-sectors of the agricultural sector, as well as rural areas should be established.

5 Conclusion

New technological, geopolitical and economic challenges make it necessary to support the sustainability of the functioning and development of domestic agriculture and the agro-industrial complex as a whole, to stimulate digital transformation and systemic modernization of the industry. It is digitalization that plays one of the key roles in the systemic modernization of Russian agriculture and has significant potential. The development of new digital technologies will actively grow, including with government support, but the digital solutions needed to achieve sustainable development of agribusiness are currently insufficient [18], which hinders the implementation of effective ESG transformation.

The use of the proposed recommendations for systemic modernization of agricultural enterprises and the industry as a whole will make it possible to ensure an increase in the economic activity of agribusiness entities and will ultimately affect the growth of financial performance of agricultural production participants, as well as the improvement of social and environmental indicators of rural development.

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