Regional agricultural production development management in line with digitalisation trends

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Abstract. The article reveals the directions to solve the problem of modernisation of agricultural production management, the use of digital technologies, and automated agrotechnical solutions to ensure food security in the country and individual regions. The object of the study is the regional agro-industrial complex, functioning and developing under the conditions of new economic and technological challenges. The purpose of the study is to form conceptual ideas about approaches to the management of agricultural production at the regional level to ensure a new quality of development of the agro-industrial sector in the conditions of global technological changes and increasing environmental uncertainty. It is concluded that the management of the agroindustrial complex of the Russian regions based on the application of digital technologies determines the nature of the functioning and development of the Russian agroindustrial complex in accordance with modern trends and challenges from the external environment.

1 Introduction

Economic sanctions imposed against Russia over the past few years have had a negative impact on the development of almost all sectors of the economy due to restrictions on financial and commodity flows, ban on imports of advanced technologies, etc. At the same time, the sanctions pressure pushes the domestic economy to develop at the expense of internal reserves and reorientation of foreign economic relations. Since 2014, the Russian Federation has been taking certain measures aimed at import substitution in various sectors of the economy. According to experts, the most successful version of import substitution was implemented in the agro-industrial complex, which resulted in the reduction of imports of almost all types of food, which made it possible to increase the level of self-sufficiency of Russian regions in basic foodstuffs.

According to the estimates of the Ministry of Agriculture, in 2022, the level of self-sufficiency of the country in the Russian Federation has significantly exceeded the set values of the "Food Security Doctrine" in the segment of grain, vegetable oils, fish and fish products (see Table 1).

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Table 1. Level of self-sufficiency (food independence) of the Russian Federation in 2022

<table>
<thead>
<tr>
<th>Products</th>
<th>The level of self-sufficiency</th>
<th>Indicator relative to the threshold value of the Food Security Doctrine of the Russian Federation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed</td>
<td>177.8%</td>
<td>1.9 times higher</td>
</tr>
<tr>
<td>Sugar</td>
<td>103.2%</td>
<td>13.2%</td>
</tr>
<tr>
<td>Vegetable oils</td>
<td>211.1%</td>
<td>2.3 times higher</td>
</tr>
<tr>
<td>Meat and meat products</td>
<td>100.9%</td>
<td>15.9%</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>84.9%</td>
<td>-5.1%</td>
</tr>
<tr>
<td>Fish fish products</td>
<td>153.3%</td>
<td>1.8 times higher</td>
</tr>
<tr>
<td>Potato</td>
<td>94.0%</td>
<td>-1.0%</td>
</tr>
<tr>
<td>Vegetables and melons</td>
<td>89.2%</td>
<td>-0.8%</td>
</tr>
<tr>
<td>Fruits and berries</td>
<td>44.9%</td>
<td>-15.1%</td>
</tr>
<tr>
<td>Food salt</td>
<td>65.2%</td>
<td>-19.8%</td>
</tr>
</tbody>
</table>

However, serious shocks caused by the geopolitical crisis and a new wave of sanctions imposed in 2022 have led to the emergence of new threats and challenges that exacerbate the problem of the efficiency of agricultural development management. Logistic and cooperation chains are being transformed, which raises the question of finding options to reduce risks and get on the trajectory of sustainable development of the agro-industrial sector of the Russian regions' economy. Therefore, the problem of developing a methodological toolkit of agro-industrial complex management adequate to modern trends and challenges using advanced technological achievements, which allows overcoming barriers and crises, providing favourable conditions for the growth of agro-industrial production at all levels of management, is actualized.

The aim of the study is to form a conceptual understanding of new approaches to the management of agricultural production and the regional agro-industrial sector in the context of increased sanctions restrictions, technological and economic challenges, changes in the institutional conditions of agribusiness.

2 Methods and materials

There is a large number of scientific works devoted to theoretical and applied aspects of digitalisation of the economy and its individual industries [1, 2], as well as studies that reveal the problems and consequences of sanctions for the economy [3, 4]. The works of domestic and foreign scientists consider various aspects of managing the development of economic systems, including in conditions of uncertainty and risks, as well as the issues of import substitution and the formation of sustainable cooperative ties that are little affected by the global conjuncture [5, 6, 7].

To achieve the set research objectives, the paper uses the main provisions of the theory of economic development, institutional-evolutionary theory, theory of public administration, which together allow us to study and solve an important scientific and applied problem of forming new approaches to the management and sustainability of the agro-industrial sector of the economy in the context of new global challenges.

The methods of system analysis of data, methods of logical and descriptive analysis were used as a methodological tool to study the issues raised about the impact of sanctions pressure on the country's economy and, in particular, on the development of the agro-industrial sector, the consequences of which were the disruption of logistics and cooperation value chains.
3 Results and discussion

Agricultural development in recent years, despite the import ban on a number of vital products and restrictions on access to foreign markets, has demonstrated high production indicators. However, it should be noted that they are ensured mainly due to record high grain yields, while the dynamics of sectors that are based on deep processing of the product and sophisticated agricultural techniques have more modest results. This is due to the influence of external and internal factors, such as the dynamics of market conditions, the level of costs per unit of production, the state of fixed assets, the disruption of traditional logistics chains, fluctuations in demand, etc., which forces the AIC system to balance on the edge of profitability. Only large players of agribusiness are able to demonstrate positive profit dynamics, largely due to support from the state.

The peculiarity of agricultural production is its conservatism (compared to other industries), strong dependence on weather conditions and natural phenomena, as well as the impossibility to structure all business processes in advance. In modern conditions, the production process in agriculture cannot take place without proper provision of the industry with means of production, feed, seeds, plant protection products. This requires an appropriate system of their supply.

At present, the dependence on imports of animal feed and feed additives is quite high: about 50 per cent of amino acids, about 90 per cent of feed additives and microelements and almost 100 per cent of vitamins are supplied from abroad. Therefore, it is necessary to develop domestic production of animal feed, to develop domestic technologies for the production of additives, to train qualified personnel in this field, and to reduce the negative impact on the environment.

An important component is the development of breeding and seed production of oilseeds. In this area, over the past five years, the Russian agro-industrial complex has almost doubled its production figures, but the volumes are largely provided by seeds of foreign selection. In 2023, a federal state information system "Seed Production" was created in the Russian Federation. All participants of seed turnover, who are engaged in testing, production, quality control, storage, sale and use of seeds of agricultural plants, are now obliged to provide information to this system.

Recently, there has been increasing talk about the formation of a model of development of domestic agricultural production, combining the features of horizontal and vertical integration, which is characterised by an emphasis on the search for institutional factors and drivers of sustainable economic development of the agro-industrial sector.

At present, due to the pronounced need to adapt the agro-industrial complex to the sanctions confrontation and the changed conditions of functioning of the agricultural products market, there is a need for a systematic analysis of institutional factors of development of domestic agriculture. For example, the problem of coordinating the activities of managers of different levels in the sphere of agro-industrial production (municipal, regional, national), the problem of attracting investment resources in this sphere, as well as the spread of self-organisational processes, which are manifested through the inclusion of broader layers of farmers, individual producers (along with large agricultural holdings) in property relations, in management processes, in solving priority problems of the industry development. Institutions should ensure wider participation of small agricultural producers in the transformation of the industry, in the implementation of the programme of its digitalisation and technological modernisation.

The transformation of agricultural production management based on institutional factors at the stage of its digitalisation and adaptation to changed conditions is a complex task, since the solution to this problem is carried out in conditions of uncertainty, ambiguity of
consequences, and the problem itself is characterised by poor structuring and multidimensionality.

Uncertainty is manifested in the fact that the nature of the reaction of agribusiness entities to large-scale transformations in connection with the imposed sanctions and countermeasures is not rigidly deterministic and can only be described by scenario development options. In addition, the external conditions of agribusiness development that have developed in each particular region, related to the specifics of the regional environment, existing formal and informal institutions, etc., are also uncertain.

The weak structuring of the above problem is manifested in the fact that it contains a large set of parameters (quantitative and qualitative), which cannot be strictly formalised. Therefore, it is impossible to unambiguously model the optimal institutional conditions and determine the degree of their impact on the processes taking place in AIC, to justify the choice of instruments to influence the innovative and technological development of AIC, to optimise the allocation of resources for this area of development.

The ambiguity lies in the presence of several possible options for solving the problem. There are several different ways of development of the agro-industrial sector in each region, different potential opportunities determined by the internal and external environment, institutions and other factors of endogenous and exogenous nature, which can change rapidly, and depending on this, different options for the development of the agro-industrial complex or its individual sectors can be realised.

The multidimensionality of the problem lies in the fact that the decisions taken in the field of institutional regulation and management of the agro-industrial sector will inevitably affect all other aspects of functioning and development of agriculture: social, environmental, technological, financial, etc. Attempts to ignore any of these aspects will inevitably lead to the adoption of inadequate decisions and, accordingly, will not allow getting closer to achieving the set goals. Decision-making on the management of such complex objects as the agro-industrial complex, taking into account its economic and social importance for the entire economy of the country, should be carried out in accordance with the regulatory documents adopted in the framework of the state agricultural policy, the directions of agricultural development in each region, the programme of digitalisation of this sector and the established global trends in the development of AIC.

We highlight the following main trends that have a significant impact on the development of agricultural production in the regions and the agro-industrial sector as a whole:

- digitalisation, emergence of new technologies, expansion of applications of artificial intelligence, biotechnology, electronics, etc. in the agro-industrial sector;
- expansion and increasing complexity of global value chains in world food production;
- increasing global challenges to sustainable development, including growing environmental, social and digital inequalities;
- increasing entrepreneurial initiative through support for SME development in the agribusiness sector combined with digital transformation.

In the framework of this study, we will touch upon the prospects of agribusiness development in the regions in accordance with the trend of digitalisation and the use of new technologies in agriculture, as well as the digital imperatives of adaptation of the agribusiness sector to the conditions of the new reality in which agribusiness entities are forced to operate and develop.

The Russian Government has allocated 907 million rubles in 2022 for the introduction of digital technologies in the Russian agribusiness sector (Russian Government Order No. 1403-r of 2 June 2022). The volume and quality of application of modern technologies, including data collection, storage and processing systems, is increasing in AIC. Data from satellites, sensors, and operating systems are used. At the same time, the volume of data is increasing,
as is the need for quality data processing and reliable conclusions that can be relied upon when making decisions.

One of the trends within the digital trend in agriculture is the spread of precision farming systems. Precision farming systems are characterised by the use of advanced land management technologies and big data for more efficient and sustainable farming. The main results achieved through the application of precision farming are increased yields, improved quality and minimised costs of agricultural products, reduced environmental impact, improved land quality and improved management efficiency of agricultural enterprises. The leaders in the introduction of the latest technologies are: USA, Germany, Japan, Denmark, Holland, Brazil, Australia and China, where the level of implementation of precision farming reaches 60% - 80% [8].

The main obstacles to the use of precision farming in Russia are costliness and technical complexity, which is aggravated by the shortage of personnel in this area. If the first problem can be overcome with the help of government support, the second requires, firstly, time to "grow" the necessary specialists, and, secondly, the formation of attractive conditions for highly qualified IT specialists to work in the industry.

The precision farming system can be presented as a management concept based on a multitude of individual technologies that can be used either all at once or separately depending on the tasks to be solved. The experience of using precision farming technologies in Russia is 10 years, but the spread of such systems remains at a low level compared to other countries. According to some estimates, about 10% of farms use precision farming solutions to some extent. The most common elements of precision agriculture in Russia are geospatial mapping, use of special programmes for data collection and analysis.

Another modern trend in agricultural development is the development of industries related to deep processing of grain crops. Multistage technology allows to obtain a wide range of products with high added value: starches, glucose-fructose syrups, starch molasses, glucose, gluten or gluten, food alcohol and biofuel, biogas, feed additive and others.

Specialists conventionally distinguish three stages, each of which produces different products. All standard products that concern native starches are obtained in the first stage of processing. This product has little added value, the starch market in Russia is close to saturation, but despite this, there is still potential for growth in output. The second stage of processing is realised at more technologically advanced facilities and makes it possible to obtain products with high added value, the main consumers of which are food production and agriculture. The most interesting, in terms of development prospects and the application of digital technologies, is the third stage of processing, which makes it possible to obtain products that can become a substitute for chemical industry products. We are talking about the production of various types of biopolymers and bioplastics, etc.

In addition to the above-mentioned areas, the development of deep processing technologies makes it possible to cover the deficit of feed, vitamins and amino acids (see Figure 1) required by livestock and poultry farms.

Fig. 1. What Russia lacks for food production
The next trend in AIC development is the development of technologies in the field of "smart agriculture". According to expert estimates, subject to mass adoption, artificial intelligence can provide an increase in gross value added (GVA) by 2025 by 25 per cent in crop production and 13 per cent in livestock farming. The industry demonstrates a high degree of readiness to utilise almost all technologies that exist in the digital economy. This is primarily due to the prospects for reducing agricultural production costs (Figure 2).

Over the last 5 years, the average number of employees in agriculture has decreased by 244.2 thousand people, which is more than 19% for the industry (according to the Ministry of Agriculture of the Russian Federation), while in the economy as a whole this reduction was 2.4%. The introduction of digital technologies in the agro-industrial complex will allow enterprises to solve production tasks with fewer human resources.

Digital technologies are playing an increasingly important role in agriculture, improving production processes, optimising the use of resources and increasing crop yields. The use of the following digital technologies in agriculture has the greatest impact:

- automated farm management systems, which automate many labour-intensive processes in AIC, such as animal feeding, farm animal disease control and other functions, thus optimising production;
- precision agriculture, involving the use of GPS and sensors, which allows optimising the use of fertilisers, water and pesticides based on an analysis of the real needs of each plot of land, as well as reducing costs and negative environmental impact;
- drones and unmanned technologies that are used to monitor fields, making it possible to detect problems important to agriculture such as plant diseases or lack of water. They can also be used to spray fertilisers and pesticides, making the process more efficient;
- data analysis and artificial intelligence. By collecting and analysing data on soil, climate, yields and other factors using artificial intelligence, agricultural businesses can make more informed decisions, optimise production and increase yields;
- blockchain technology to create transparent and secure accounting systems for agricultural products, which is important for ensuring product quality and authenticity;
- the Internet of Things (IoT), which allows agribusiness entities to monitor the condition of agricultural machinery, stockpile products and track their progress in digital markets, improving delivery efficiency and reducing losses;
- utilising digital twin technology in agriculture. By creating virtual copies of objects and processes, this technology makes it possible: to conduct breeding experiments on plants...
and animals, significantly reducing the time and costs of obtaining results; to forecast and model the state of real crops, etc.

A few words about the main problems that arise when using digital technologies in agriculture. Firstly, it is compatibility (combinability) - the ability of an element to be combined with other elements. In digital technologies, compatibility refers to the ability of applications and architectures to interact with each other. According to Gartner research, high levels of compatibility help reduce costs and eliminate a lot of software from interoperating with each other;

In essence, software components are the building blocks that can be used to build a structure. Componentisation means that it is easy to make changes to the design when needed, simply by adding new modules or removing old ones. Composable architecture is based on flexible technologies, such as APIs - a description of how one computer programme interacts with others. It has been proven by experts that a few elements, properly linked together, can yield exponential value. Experts have calculated that only 6% of companies on the market can boast of a high level of componentisation.

According to statistics, about 70% of initiators of digital business transformation do not achieve the planned results, and most of the funds allocated for this purpose are wasted. At the same time, the digitalisation goals are not achieved, but reporting on the use of the funds allocated for digitalisation is a success.

Another important problem faced by agribusinesses is the shortage of qualified specialists. In Russia, there is approximately one IT specialist per 1,000 people employed in agriculture, and in total there are about 112.9 thousand IT specialists in the agricultural sector, or 2.4% of the total population employed in agriculture.

To achieve the same indicator as in the leading countries (USA, Germany, UK), Russia needs another 90 thousand IT-specialists in agriculture (Fig. 3).

![Fig. 3. Share of IT specialists in agriculture as a percentage of the total number of employed persons in the agro-industrial complex](image)

One of the main factors of staff shortage in agriculture is the low level of wages in this sector of the economy and the low attractiveness of the social sphere in rural areas. According to experts, the difference between the level of labour remuneration in agriculture and in urban areas is estimated at 60%. Improvement of working conditions, development of the social sphere and elimination of the digital divide, combined with higher wages, can lead to an increase in the attractiveness of work in rural areas for highly qualified specialists. But this requires a change in the approach to agribusiness management, transforming it towards the use of ecosystem methodology combined with digital transformation. Digital ecosystems provide a wide range of opportunities for all market players: access to advanced technologies,
training opportunities and dissemination of good business practices, including in agriculture. And digital platforms provide agrarians with access to producers' markets, customer and service markets, analytical data, and others. The creation of the ecosystem will make it possible to increase the attractiveness of rural areas for young people and qualified specialists, to ensure more effective interaction within the framework of solving common problems of strategic development of agriculture, as well as to form partnerships of participants for further development and search for reserves to improve the efficiency of the agro-industrial sector.

Thus, the solution to the problem of effective development of the agrarian sector of the economy in the regions, implementation of the shift towards a wider use of digital technologies in agriculture, first of all, lies in the plane of institutional transformation and change of the management model in the direction of creating ecosystems in the agrarian sector of the region, implementation of modernisation programmes for the leading branches of agriculture. An important prerequisite for overcoming the negative trends and barriers to the digitalisation of agriculture is the improvement of state regulation of agricultural development, coordination of strategies and plans for sectoral and territorial development at all levels of management within the framework of a common vision of the main ways of developing the agro-industrial potential of the regions.

4 Conclusion

The Russian Federation is currently lagging behind in the development of IT and digital technologies, it is on the way to forming its own digital market, and the agro-industrial complex is still an area with undiscovered digital potential. The path to digital agriculture in Russia lies through the development of the domestic agricultural production market, the use and consumption of information, communication and digital technologies. The application of digital technologies in agriculture helps to improve sustainability of production, increase yields and reduce the negative impact on the environment, making agriculture more productive and sustainable.

On the part of the state, there are policies to support agricultural producers, development of the institutional environment, legislative regulation, and allocation of resources. However, given the actualisation of the task of transition to digital agriculture, it is necessary to make adjustments to the current system of regional management of the agro-industrial sector.

Technologically, digital agriculture is an environment in which legal entities and individuals can freely contact each other about joint IT-based activities. Therefore, to ensure the transition of regional agriculture to the digital model of development, it is advisable to form a mechanism within the regional management system that will stimulate the formation and development of agro-industrial ecosystems, and enterprises and households to actively use progressive digital technologies.

In reality, the process of transition of regional agriculture to digitalisation may occur in different ways, so the transition mechanisms may be different. Taking into account the peculiarities of Russian regions, their specifics, the huge variety of regional conditions and target settings, three types of mechanisms for the transition of regional agriculture to the digital model can be implemented: inertial (liberal), stimulating and regulating (rigid).

For a group of regions that, for various reasons, are not ready for digital transformation and mass use of new technologies in the agro-industrial sector, the rigid, regulatory mechanism is most suitable. For the leading regions, where agriculture is actively developing and which have high availability of all types of strategic resources, including digital resources, a liberal transition mechanism can be used. And for the group of regions with average conditions, an incentive mechanism is suitable, which involves the use of various
tools and methods to stimulate the use of digital technologies in the agricultural sector of these regions.

In this situation, the activities of state structures at the regional level should be aimed at ensuring:

− sustainable and secure digital infrastructure in rural areas;
− the necessary level of education of the rural population, including digital literacy;
− conditions for attracting intellectual resources to rural areas;
− reducing the digital divide (inter- and intra-regional);
− stimulating more active formation and development of agro-industrial ecosystems;
− perspective forecasting and formation of guidelines for the development of the agricultural sector on this basis.

The use of the proposed recommendations in the practice of management of the agricultural sector of the regional economy, as well as the use of high-performance decision support systems will ensure an increase in the economic activity of agribusiness entities and will ultimately affect the growth of performance indicators of agricultural production and improvement of social indicators of development of rural areas, regions and the country as a whole.

References


