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FORMING A MODEL OF INNOVATION ACTIVITIES OF THE AGRO-INDUSTRIAL COMPLEX AS THE BASIS FOR ITS SUSTAINABLE DEVELOPMENT

FORMAR UM MODELO DE ATIVIDADES DE INOVAÇÃO DO COMPLEXO AGROINDUSTRIAL COMO BASE PARA SEU DESENVOLVIMENTO SUSTENTÁVEL

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ABSTRACT

Objective: The study considers a model for the sustainable development of innovation activity in the integrated structures of the agro-industrial complex to overcome low rates of innovation activity in Russia. **Methods**: To achieve this objective, the authors analyze the sources of information and study the current state of innovation. They develop a model for the sustainable development of innovation activity in the integrated structures of the agro-industrial complex, including seven consecutive blocks: initialization, marketing, production (sales), promotion, evaluation, and diffusion of innovations. **Results**: Each block of the model is embedded in an automated structure, which ensures the accuracy and efficiency of innovation processes. A system of indicators is also introduced to assess the development of innovation activity in agribusiness. **Conclusion**: The conducted research allows the authors to conclude that it is necessary to apply the model of sustainable development of innovation activity in the integrated structures of the agro-industrial complex to increase the indicators of innovative development in Russia. An automated structure embedded in each block of the model ensures the accuracy and efficiency of innovation processes, speeds up their implementation, and increases efficiency. The system of indicators is used to assess the current development of innovation activity in the agro-industrial complex and serves as an important tool for monitoring and managing this process.

Keywords: Innovation activity; Sustainable development; Efficiency; Agro-industrial complex; Indicators.

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RESUMO

Objetivo: O estudo considera um modelo para o desenvolvimento sustentável da atividade de inovação nas estruturas integradas do complexo agroindustrial para superar as baixas taxas de atividade de inovação na Rússia. **Métodos:** Para atingir esse objetivo, os autores analisam as fontes de informação e estudam o estado atual da inovação. Eles desenvolvem um modelo para o desenvolvimento sustentável da atividade de inovação nas estruturas integradas do complexo agroindustrial, incluindo sete blocos consecutivos: inicialização, marketing, produção (vendas), promoção, avaliação e difusão de inovações. **Resultados:** Cada bloco do modelo está incorporado em uma estrutura automatizada, que garante a precisão e a eficiência dos processos de inovação. Um sistema de indicadores também é introduzido para avaliar o desenvolvimento da atividade de inovação no agronegócio. **Conclusão:** A pesquisa realizada permite aos autores concluir que é necessário aplicar o modelo de desenvolvimento sustentável da atividade de inovação nas estruturas integradas do complexo agroindustrial para aumentar os indicadores de desenvolvimento inovador na Rússia. Uma estrutura automatizada incorporada em cada bloco do modelo garante a precisão e a eficiência dos processos de inovação, acelera sua implementação e aumenta a eficiência. O sistema de indicadores é usado para avaliar o desenvolvimento atual da atividade de inovação no complexo agroindustrial e serve como uma ferramenta importante para monitorar e gerenciar esse processo.

Palavras-chave: Atividade de inovação; Desenvolvimento sustentável; Eficiência; Complexo agroindustrial; Indicadores.

1 INTRODUCTION

The formation of a model of innovation activity of the agro-industrial complex is important for the modern market of agricultural products. Currently, the global economy is rapidly developing, which requires companies operating in this market to adapt and improve their innovative technologies and processes.

The Russian agro-industrial complex is currently at the stage of transition to a digital economy, which involves the widespread use of new digital technologies and an increase in automation. Organizations working in the field of agriculture should be able to quickly respond to external changes and take measures to accelerate the search for and implementation of new technologies.

The formation of a model of innovation activity in the agro-industrial complex will help companies create an effective innovation process that will develop new products and services, improve the quality of products, reduce costs, and increase production efficiency. This model will allow agribusiness organizations to become more competitive and stable in the market.

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This study considers scientific issues from several aspects at once. These are innovation activity, efficiency, and sustainable development of the agro-industrial complex. All these aspects are interconnected.

The research objective is to introduce and test a model for the sustainable development of innovation activity in the integrated structures of the agro-industrial complex.

2 MATERIALS AND METHODS

In the first stage, we studied scientific works by economists on the theory and practice of organizing innovation activities, as well as the sustainable development of the agro-industrial complex. Such studies were retrieved from the Scopus and Web of Science citation databases.

In the research process, we used the following general scientific methods: monographic, abstract-logical, economic-mathematical, and comparison.

3 RESULTS AND DISCUSSION

3.1 Review of the theory and practice of sustainable development of the agro-industrial complex

For a start, we should consider different approaches to the definition of innovation activities of the agro-industrial complex.

The Austrian scholar J.A. Schumpeter was the first to highlight the economic importance of innovation. Schumpeter mentions innovation as a method of overcoming crises by introducing new technologies. Schumpeter (1982) believes that innovation cannot improve production but radically changes its functions consisting of a new connection between the means of production.

Agricultural activity has its specifics; it is worth mentioning innovation activity in the context of the agro-industrial complex.

Many authors have tried to determine the role of innovation in agriculture, including P. Aerni (2015), J. Gardasevic, I. Brkic, and T. Krstic (2020), A. Pigford, G. Hickey, and L. Klerkx (2018), E. Bennett and S. Carpenter (2014), A.I. Bogachev (2019), and L. Klerkx and D. Rose (2020).

According to P. Aerni et al. (2015), innovations in the agro-industrial complex are the introduction of new products, processes, and structures for socio-economic use.

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For small- and medium-sized organizations, there is a problem that these enterprises resort to traditional methods of farming and believe that these methods are more effective than new technologies (Gardašević et al., 2020).

According to A. Pigford et al. (2018), agriculture should give priority to innovative and sustainable agriculture to save:

- Land;
- Water;
- Animal genetic resources;
- Plant genetic resources.

Sustainable agriculture is efficient in terms of economic, technical, environmental, and social characteristics.

The transition to an innovative and sustainable agro-industrial complex raises several problems (Bennett et al., 2014):

- Competition for land, water, and energy;
- Developing markets;
- Rural development;
- Climate change;
- Ecosystem health.

Russian authors have their idea of the problems associated with innovation. A.I. Bogachev (2019) highlights unique factors limiting the transition to an innovative level of the agro-industrial complex, including “tough competition, inflationary processes, declining demand, insufficient investment in fixed assets, and the need for import substitution” (p. 97).

Despite all the problems and challenges, L. Klerkx and D. Rose believe that there are technological advances in the field of agriculture that affect all economic entities. These innovative technologies caused the Fourth Agricultural Revolution. This revolution is characterized by high technology, radicalism, and ever-changing technology (Klerkx & Rose, 2020).

Thus, innovation activity is the creation and implementation of new technologies, products, and services that can increase the competitiveness and efficiency of agribusiness.

It is worth considering the concept of efficiency for a more detailed definition of the issues mentioned above.

There are a large number of concepts of efficiency. Let us consider some of them.

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In 1906, the Italian economist V. Pareto wrote his “Manual of Political Economy”, which is considered the basis for the theory of economic efficiency (Pareto, 2023). Currently, Pareto’s efficiency is classified as “the state of a system in which it is impossible to improve any of its elements so as not to worsen its other elements”. Almost a century later, one of the Russian economists, O. Sukharev, argued that this study should be analyzed more specifically and gave a definition of efficiency. In Sukharev’s opinion, efficiency is a relative concept (Sukharev, 2008).

M. Meskon, M. Albert, and F. Khedouri conceptualize this topic as a problematic interpretation of efficiency. Subsequently, efficiency should be viewed as the market value of products divided by the total cost of an organization’s resources (Meskon et al., 1997).

The renowned economist A. Thomson (1998) claims that “efficiency is the relationship between the number of production sources used in an enterprise and the quality of products made using these sources” (p. 46).

A unique definition of effectiveness was given by D. North, a leading supporter of the institutional approach. The scholar also concludes that “efficiency is a system that reproduces the conditions for economic growth because only economic growth increases wealth” (North, 2010, p. 95).

V.T. Denisov et al. (2010) argue that the efficiency of production in an open economic system could be regarded as a management decision to ensure the sustainability of an enterprise and change its quality aimed at meeting individual, collective, and social needs.

M.V. Kosolapova and V.A. Svobodin (2018) believe that efficiency is the degree to which an organization achieves its goals determined by a system of economic laws related to individual reproduction.

The most important step in managing the factors that affect the efficiency of an organization’s economic activity is their assessment. Methods for assessing the economic efficiency of an enterprise are crucial elements of management and control and use both quantitative and qualitative approaches.

After conducting a scientific study on this topic, we proved that there are several issues regarding the consideration and systematization of effectiveness.

Firstly, efficiency in the agro-industrial sector should be viewed from an agricultural perspective, i.e. in relation to ecosystem-based and natural-climatic approaches. Secondly, the years-long formation of a market economy has seriously increased the opportunities for more comprehensive research of interests aimed at studying

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efficiency in terms of its interaction with sustainable development, globalization, the financial situation, and the integration of new systems for calculating the effectiveness of the agro-industrial complex. This suggests that efficiency should be developed in relation to its most basic area of activity, i.e. the resource potential of agricultural territories.

Many economists classify the efficiency of the agro-industrial complex into four types:

– Technological;

– Economic;

– Social;

– Environmental.

The concept of sustainable development was formed in the second half of the 20th century due to military conflicts, social tensions, and environmental degradation threatening the existence of humankind (Bigg, 2004; Elliot, 1994).

V.I. Vernadskii (2012) was the first scholar who drew attention to the ecological safety of society and the environment. Further, international scientific and technical conferences on nature protection held under the auspices of the United Nations consider environmental protection and seek new strategies for economic development.

Secretary General M. Strong notes that it is impossible to achieve the social and economic well-being of countries while maintaining the same level of natural resources (Becker, 2000). Thus, the transition to sustainable development began in developed countries.

The term “sustainable development” was introduced by G. Harlem Brundtland. According to Harlem Brundtland, sustainable development is the development that can meet the growing needs of modern society and not jeopardize the ability of future generations to satisfy their needs (World Commission Environment and Development, 1987).

The concept of sustainable development involves a continuous process of interaction between three main areas: economic, environmental, and social.

The economic component of sustainable development is based on the Hicks-Lindahl theory of the maximum income flow and implies the optimal use of limited resources (Chepurnykh et al., 2000).

The social sphere of sustainable development involves ethical problems of organizing and maintaining citizenship.

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The environmental component deals with the impact of business on the environment, as well as its adaptation to changing natural conditions.

The fight against environmental degradation and climate change has revealed a set of standards that organizations must meet to function effectively and develop their activities. Thus, K. Annan, the former Secretary General of the UN, formed the principles of sustainable development (ESG), which stand for (United Nations, 2004):

Environmental principles involving respect for the environment;

Social principles implying a loyal attitude of the company to its staff, as well as social responsibility;

Governance principles comprising effective and high-quality management, as well as the fight against corruption.

ESG principles are implemented in the agro-industrial complex since their effective functioning, investment climate, and innovative development largely depend on the environmental, social, and management components.

Thus, innovation activity, efficiency, and sustainable development of agribusiness organizations are closely related and interdependent. Through innovation, efficiency can be increased, and its improvements can lead to sustainable development.

Today Russia is in the top 50 countries in terms of innovation development.

The Global Innovation Index is a global ranking of countries around the world in terms of their innovation development. This study is conducted by the World Intellectual Property Organization and the INSEAD international business school. Table 1 presents several countries with their innovation index for 2020-2022 (the data is based on the Global Innovation Index for 2020-2021 and 2022 (Dutta et al., 2022)).

Table 1. Innovation indices of some countries and their ranking

Country	2020		2021		2022	
	Ranked	Index	Ranked	Index	Ranked	Index
Switzerland	1	66.8	1	65.5	1	64.6
USA	3	60.6	3	61.3	2	61.8
South Korea	10	56.1	5	59.3	6	57.8
Germany	9	56.5	10	57.3	8	57.2
China	14	53.3	12	54.8	11	55.3
Russia	47	35.6	45	36.6	47	34.3

Source: compiled by the authors

Switzerland has been ranked first for three years and has the highest score.

For three years, the USA has had almost the same indices. In 2022, it secured the 2nd position in the world ranking.

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South Korea made a great leap in 2021, climbing up five positions, but one year later dropped to the 6th position.

The German index has not fluctuated much over the past three years but had risen in the ranking by 2022.

China improves its performance every year. In 2022, it reached the 11th position in the ranking.

In 2020 and 2022, the Russian Federation occupied the 47th position in the world ranking. Only in 2021, Russia managed to move two positions higher and increase its innovation index. Russia entered the group of countries with indicators corresponding to the development of countries with an upper-middle income.

Figure 1 traces the change in the indicators of all countries and their values over three years.

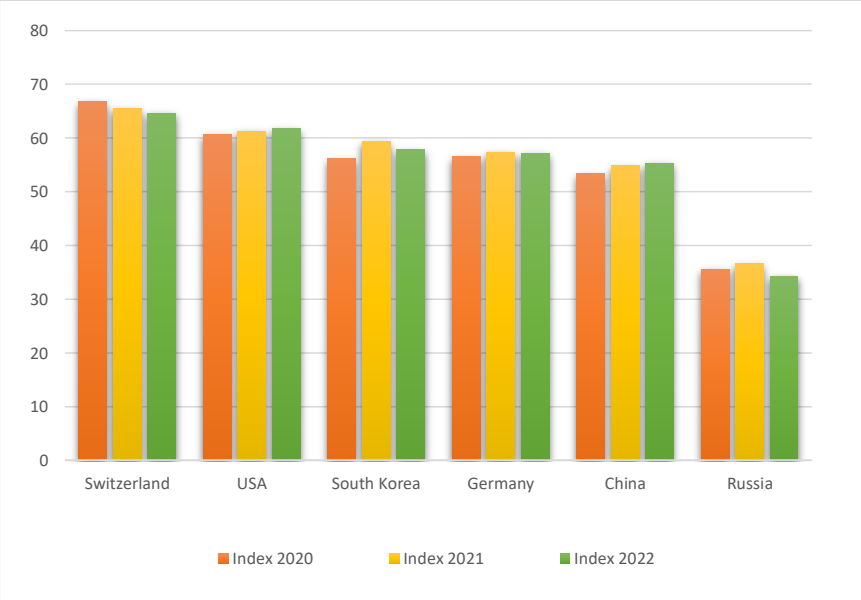

Figure 1. The chart of the Global Innovation Indices in some countries (2020-2022)
Source: compiled by the authors based on the Global Innovation Index (Dutta et al., 2022)

Russia has indicators that are significantly different from those of the top 10 countries. The main disadvantages of the Russian innovation activity within the Global Innovation Index are as follows:

1. Underdeveloped legislative framework in the field of innovation;
2. Lack of conditions for innovation;
3. Policy in the field of business development and entrepreneurship;
4. Insufficient funding for start-ups.

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In the context of innovations in the agro-industrial complex, the following data from the Federal State Statistics Service (n.d.) can be presented (Table 2).

Table 2. Costs for innovation activities in Russia for 2019-2021 (million rubles)

Activities of the agro-industrial complex	**2019**	**2020**	**2021**
Growth of non-perennial crops	38,976.1	22,553.6	16,608.4
Growth of perennial crops	62.4	3,560.5	4,724.2
Plant propagation	11.6	-	-
Cattle breeding	10,002.9	12,936.8	9,301.2
Mixed farming	65.3	-	-
Ancillary activities in the field of crop production and post-harvest processing of agricultural products	274.9	373.5	1,509.8

Source: data from the Federal State Statistics Service (n.d.)

Ancillary activities in the field of crop production and post-harvest processing of agricultural products are the most popular type of innovation activities and have increased these costs over the past three years.

Despite cost reductions in 2021, growing non-perennial crops is the most promising in terms of innovation, if compared to growing perennial crops. The innovation activity focused on the cultivation of perennial crops increased 57 times in 2020 compared to 2019.

Innovations in animal husbandry reached almost 13 billion rubles in 2020 but decreased in 2021 and became lower than those in 2019.

Although the costs of innovation for various types of agricultural activities were significant, Russia is still ranked 45+ in conformity with its level of innovative development. One of the methods that can enhance the innovation development of agribusiness will be discussed further.

3.2 Sustainable development model of innovation activity in the integrated structures of the agro-industrial complex

Based on the theoretical and practical analysis, we developed a model of innovation activity to organize this activity within the framework of the sustainable development of agribusiness (Figure 2).

In the presented model, innovation activity is divided into seven blocks implemented in chronological sequence. These are as follows: initialization, marketing, production (sales), promotion, evaluation, and diffusion. To ensure the accuracy and efficiency of all the processes, these blocks are put into an automated structure.

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For effective work with innovations, it is important to transform the organizational structure of agricultural holdings, with the mandatory introduction of an innovative development department and a management accounting department.

The department of innovative development coordinates innovation activities in an organization. Its functions include the development of target indicators and indices that assess the innovative development of an organization. This department monitors the deviations of estimated indicators and provides prompt responses to their abrupt changes. The generalizing document that establishes the department of innovative development reports on innovation activities.

The management accounting department is not new for agribusiness but, in this case, it has a complex information and analytical structure. The department generates reports on production activities with due regard to the social, economic, and environmental aspects of an organization.

Information from these departments is aggregated into management reporting by types of agricultural activities (Figure 2), which is transferred to management personnel. Based on management reporting, in which much attention is paid to the analytics of innovation, a set of measures is developed to optimize the sustainable development of innovation. An obligatory process in the development of measures is the assessment of the influence of internal and external factors on innovation activity (economic, technological, political, etc.) (Figure 2).

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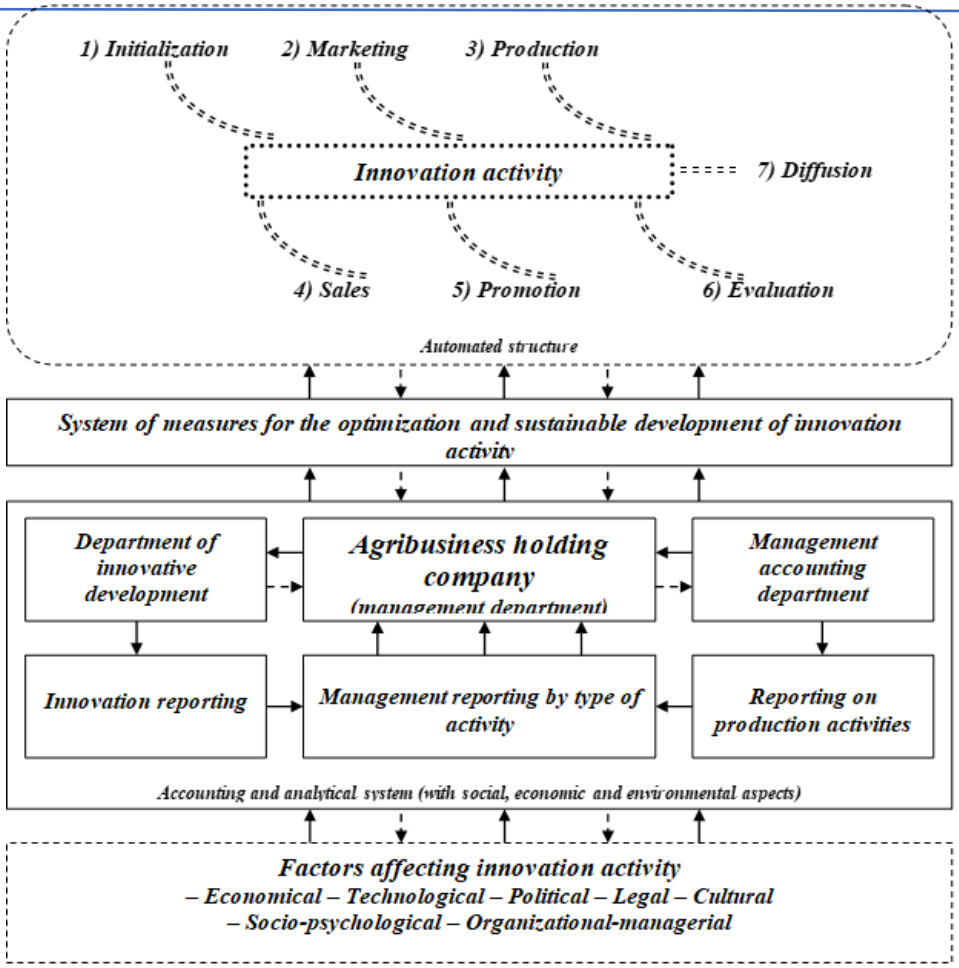

Figure 2. Model of sustainable development of innovation activity in the integrated structures of the agro-industrial complex (compiled by the authors)

Thus, the presented model contains preventive measures aimed at the prompt elimination of the negative impact on the agro-industrial complex in general and the development of innovation activity in particular. The accounting and analytical system with social, economic, and environmental aspects provides a comprehensive information basis for effective management, with the simultaneous sustainable development of innovation activities of agribusiness.

3.3 Indicators for assessing the development of innovation activity in the agro-industrial complex

Based on the model of sustainable development of innovation activity in the integrated structures of the agro-industrial complex, we can offer the following indicators for their better implementation in enterprises engaged in agriculture (Table 3).

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Table 3. Indicators for assessing the innovative potential of the agro-industrial complex

No.	Name	Formula for calculating indicators
1	Intellectual property indicator	$Ind_{int.pr.} = R_{int.} / A_{implem.}$
2	Implementation coefficient for new products	$Ind_{new.prod.} = V_{innov.prod.} / V_{prod.}$
3	Coefficient of profit from innovation activity	$Ind_{profit} = P_{innov.} / P$
4	Export ratio of innovative products	$Ind_{export} = E_{innov.} / E$
5	Investment performance ratio	$Ind_{inv.per.} = P_{innov.} / S_i$

The indicators we selected can characterize the development of innovation activity in the agro-industrial complex.

The intellectual property indicator is used to measure the level of intellectual property protection in a company. It shows the ratio of the number of registered patents, trademarks, and other intellectual deliverables, as well as the total number of products and services offered by this company.

The implementation coefficient is an important characteristic of the process of introducing a new product and measures the effectiveness of adding a new product into manufacturing. It also helps determine how much time, resources, and effort it will take to successfully launch a new product. The implementation coefficient can be used to compare processes for new product introduction across departments or companies, identify the best practices, and use more effective methods.

The coefficient of profit from innovation activity is used to assess the effectiveness of investing in innovation. It shows the ratio of the profit received from innovations to the costs of their implementation. This coefficient can help companies determine how well they invest in innovations and which innovations are worth to be developed in the future. In addition, the ratio can be used to compare the results of different projects and select the most promising ones.

The export ratio of innovative products assesses how an organization can export its innovative products to the global market. This is an important indicator of competitiveness as the effective export of innovative products can lead to economic growth, job creation, and increased export income. The export ratio of innovative products also indicates the level of innovation activity and the scientific and technological development of the organization.

The investment performance ratio is used to determine the effectiveness of investments and calculate the return on invested funds. It shows the ratio between profit and invested funds (%). This indicator helps investors make balanced decisions about which companies and projects to invest in, as well as evaluate the effectiveness

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of their investment strategies. In addition, it is used in the analysis of financial statements to improve the efficiency of businesses.

These indicators are calculated based on financial statements, therefore the coefficients reflect the policy pursued by an organization in the innovation sphere.

To understand the effectiveness of innovation activity in agribusiness, it is necessary to introduce threshold values by which this indicator should be monitored (Table 4).

Table 4. Distribution of performance values by groups

Integrated indicator for a group of coefficients characterizing the effectiveness of innovation activity	Threshold values for innovation performance			
$Ind_{inv.res.}$ = $Ind_{int.pr.}$ + $Ind_{new.prod.}$ + Ind_{profit} + Ind_{export} + $Ind_{inv.per.}$ / 5	Low (0-0.3)	Average (<0.3-0.5)	High (<0.5-0.7)	Extra high (<0.7-1)

For example, Agro-Alyans LLC specializes in agriculture. Namely, it is the largest manufacturer and exclusive distributor of products for gardens, orchards, and homes.

Let us calculate these coefficients for this company (Table 5).

Table 5. Innovative potential assessment indicators for Agro-Alyans LLC

No.	Indicator	Values				
		2018	2019	2020	2021	2022
1	Intellectual property indicator	0.2	0.34	0.43	0.39	0.28
2	Implementation coefficient for new products	0.37	0.39	0.41	0.54	0.6
3	Coefficient of profit from innovation activity	0.22	0.32	0.4	0.42	0.35
4	Export ratio of innovative products	0.75	0.61	0.45	0.53	0.65
5	Investment performance ratio	0.55	0.34	0.25	0.46	0.59

The intellectual property indicator and the investment performance ratio are starting to grow. However, Agro-Alyans LLC has average performance indicators (Table 6).

Table 6. Distribution of performance values for Agro-Alyans LLC

Integrated indicator for a group of coefficients characterizing the effectiveness of innovation activity	Values				
$Ind_{inv.res.}$ = $Ind_{int.pr.}$ + $Ind_{new.prod.}$ +	2018	2019	2020	2021	2022
Ind_{profit} + Ind_{export} + $Ind_{inv.per.}$ / 5	0.46	0.4	0.38	0.46	0.51

Table 6 shows that this company has an average level of innovation performance but achieved a slight increase in 2022. Therefore, we can predict that the indicators will increase in 2023 and 2024.

We propose to introduce these coefficients into the annual management reporting of the organization. Thus, the coefficient of profit from innovation activity can be

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included in such reports to evaluate the effectiveness of innovative projects and make decisions on their further support or rejection. The investment performance ratio of management reporting will be used to assess the effectiveness of investing funds and, if needed, change the investment strategy. The export ratio of innovative products aims at assessing their competitiveness in the world market and further developing exports.

4 CONCLUSION

Having considered the opinions of scholars on sustainable development, efficiency, and innovation, we can form the proper worldview and understanding of their role in the agro-industrial complex. The development of innovations in Russia is very slow. It is only in the top 50 countries in terms of development and lags far behind advanced countries. According to the Global Innovation Index, the funds that Russia spends on innovation for various types of agro-industrial activities do not constitute a significant amount of money. The sustainable development of innovation activity in the integrated structures of the agro-industrial complex should give impetus to development in this direction. The model is simple but includes a large set of measures for the optimization and sustainable development of innovation. The application of this model was clearly shown in the activities of Agro-Alyans LLC. Based on the company's data, we calculated the coefficients directly related to this model and concluded that they reflect the level of innovation activity, as well as the effective and sustainable development of the entire enterprise.

All things considered, innovative development makes a significant contribution to the development of the agricultural sector. The model shows the further development of this industry not only in the organizations of the agro-industrial complex but also in Russia as a whole. Multi-level nature and systematization play a major role in this area. The calculated coefficients allow us to understand that the agro-industrial complex needs to develop more intensively since it conditions the development and relevance of business and its products in the demand market.

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