Diversification source's financing of innovation and investment projects in the agro-industrial complex of Ukraine

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Abstract. The development of Ukraine's agro-industrial complex significantly impacts the country's economy as a whole, especially during martial law. The products of the agro-industrial complex have a significant share in the volume of exports and are the primary representative of the revenues of the state budget of Ukraine. Therefore, the study of the diversification of sources of financing of the agro-industrial complex is relevant. This study aims to assess the latest trends in the development of the agro-industrial complex and develop recommendations for the development of the economy of Ukraine as a whole, taking into account the conditions of wartime. During the research, historical analysis, forecasting, and abstraction were used. As part of the study, statistical data for 2019-2023 were analysed, so the number of operating enterprises of the agro-industrial complex during the analysed period decreased by 31.45%. The latest trends in the development of the agro-industrial complex of Ukraine are characterized, and the main directions of its innovative and investment development are defined. Therefore, in martial law conditions, using a project approach to innovative investment financing of agro-industrial complex enterprises, which need exceptional support, becomes even more relevant. That is why separate recommendations were given regarding sources, modern technologies, digitalization, and directions for diversifying sources of financing for innovation and investment projects in the agro-industrial complex of Ukraine.

1 Introduction

The military actions that have been going on for more than two years in Ukraine have caused significant damage to the society, infrastructure and ecology of Ukraine. Also, the consequences of hostilities have a negative impact due to the release into the atmosphere of a large amount of carbon dioxide and other greenhouse gases, not only in the territory of Ukraine but also in the climate in other regions of our mother planet. In the difficult times of the war, Ukraine is trying to develop and establish comprehensive cooperation with Western and Central European countries to achieve the corresponding European standards in the political, socio-economic and environmental spheres.

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One of the priority directions of the development of the economy of Ukraine is the development of the agro-industrial complex, the products of which are important for ensuring the world market of grain crops and preventing world hunger.

Unfortunately, during the war in Ukraine, this industry suffered significant losses not only due to the consequences of military actions, such as mines, the destruction of agricultural machinery and the occupation of territories that were used to grow many crops and vegetables. However, even in such conditions, it is possible to develop the agro-industrial complex of Ukraine due to the use of a project approach to innovative investment financing of this sector and the introduction of the latest priority directions and the latest technologies, such as precision agriculture, digital farming, robotics and automation of equipment, as in crop production, and animal husbandry, as well as the circular economy and the use of biofuels, which will help reduce CO2 emissions and reduce ammonia emissions in agriculture.

That is why the issue of financing the enterprises of the agro-industrial complex of Ukraine and the use of various sources of financing of innovative and investment projects of the agricultural sector is very relevant in modern conditions of development. Which requires the study of problems not only of a theoretical, but also of a practical nature, highlighting the sources of providing not only the processes of restoration of natural resources, but also the financing of innovative and investment projects of agricultural enterprises and farmers of various forms of ownership and sizes in order to increase the level of their competitiveness on the domestic and foreign markets . Questions of the theory and methodology of modernization's production and economic activity of enterprises of the agro-industrial complex, taking into account the principles of frugal production and preservation of the environment, were considered by many scientists in Ukraine [1, 2, 14, 15].

The purpose of this work is to study the diversification sources of financing of innovation and investment projects of enterprises of the agro-industrial complex of Ukraine, as an opportunity to intensify their innovation and investment activities in war and post-war periods. Development of scientifically based recommendations on the implementation of an effective model of investment and innovation activities of enterprises of the agro-industrial complex in Ukraine.

2 Materials and methods

The research was conducted in the time interval from 2019–2023, since this period covers not only the pre-war period, but also the time of full-scale military operations, which will allow to take into account the assessment of the latest trends in the development of the agro-industrial complex in Ukraine. The main source of such information is the data of the State Statistics of Ukraine [3]. The information from this source was used to assess the basic performance indicators of enterprises of the agro-industrial complex in the main directions: crop and livestock production and to determine the distribution of their performance indicators.

Data characterizing the state support of agricultural sector enterprises in the main areas was taken from the website of another body of the Ministry of Agrarian Policy and Food of Ukraine [11] and the State Agrarian Registry [16], which facilitate access to data due to the structured information provided on them.

During the research, the authors suggested summarizing the data provided by the State Statistics of Ukraine regarding the maximum simplification, understanding and presentation of data in order to improve the quality of conditions for the development's agriculture in Ukraine. However, during data collection, certain difficulties sometimes arise due to the absence of part of the data and the delay in their publication.

Thus, in terms of the volume of state support for the industrial complex, according to some indicators, data for 2022-2023 are completely absent, which hinders the possibility of calculating forecast data, especially in individual's terms elements and directions, which complicates the study. What forced the authors to consider the state of the agro-industrial complex as a whole and combine certain data.

This approach provided the authors with an opportunity to evaluate the average value of changes in financing and development's certain branches of agriculture in Ukraine. The work also considered the directions of state support for financing enterprises of the agro-industrial complex in Ukraine. The assessment of agricultural indicators of Ukraine was carried out using the correlation heat map method. Assessment of the distribution of financial resources according to the main directions of state support of the agro-industrial complex of Ukraine.

The main approaches used during the research were systematic in nature, which helped to analyze selected elements as components of a single system and to prove their interaction and their impact on modern trends in the agro-industrial sector of Ukraine. The use of a significant number of different research methods, such as the historical method, when examining data on the state of the agro-industrial complex of Ukraine over the past 3-5 years, helped to form conclusions about its current state. The methods of determining the central tendency, correlations and graphics helped to form assumptions and make a forecast regarding the possible development of the agro-industrial complex of Ukraine and its economy in the future. The abstraction method helped to make assumptions about limiting the number of factors, taking them into account during research and assessment of the development's the agro-industrial complex of Ukraine. Outlined above, provided an opportunity to increase the degree of effectiveness of the conducted research with an increased level of their accuracy and clarity.

3 Results and discussion

The GDP of Ukraine in 2022 decreased by 30.4%. In contrast, in 2021, GDP growth was 3.4%. In 2023, the real GDP of Ukraine recorded an increase of 5-5.5%, and in 2024, the real GDP increased by 3.6% [3;4]. This, in turn, contributed to maintaining high budget expenditures at a sufficient level thanks to the expected volumes of international aid. However, the rate of economic growth compared to 2023 will be lower, due to the expected decrease in harvests and the strengthening of disparities in the labor market in the conditions of war.

In addition, the destruction of the Kakhovskaya HPP caused damage to agriculture in Ukraine, namely, the water supply of 31 field irrigation systems in Ukraine was suspended: Dnipropetrovsk region - 30%, Kherson region - 94% and Zaporizhzhia region - 74%, in particular in Kherson region - flooding of 10 thousand was recorded .ha of agricultural land [5], including a significant share of land under occupation that requires surveying and demining, which makes it impossible to use the land for agricultural purposes. This indicates that agro-industrial complexes need to change the vector in the types of agriculture, using alternative sources of water supply. It is generally known that the countries of the European Union are trying to increase their economic growth thanks to the implementation of innovative, inclusive and sustainable development. The triad of the modern approach to the development of the agro-industrial complex should focus on the problems of system-wide transformations thanks to the formation of relations between the process participants on the terms of partnership (state-business-society).

At the same time, taking into account the global nature of the development's international trade relations in the world economy, the improvement of the investment activity of the agro-industrial complex in Ukraine during the martial law and in the post-

war period of the reconstruction of the state's economic system will always be the object of close attention for scientists and the main subjects of investment activity in Ukraine. However, there is no consensus on the definition of investment and innovation activity. It should be noted that the current legislation of Ukraine does not distinguish investment and innovation activities in the agricultural sector.

In our opinion, innovation and investment activity in the agrarian sphere is a set of measures and practical actions of the state, legal entities and society aimed at creating, implementing and implementing innovations through the implementation of investment projects in the agrarian sphere with the aim of obtaining profit. This will contribute to the accumulation of the necessary financial resources to finance the development of the agrarian sector of the economy and increase the competitiveness of agricultural production.

The problem of eliminating the dependence between the size of resource use and the environmental consequences of ecological growth requires the introduction of "green investments" that deserves special attention. It is generally known that investments at the expense of budget funds are essentially budget expenditures. Therefore, strategies for the development of enterprises the agro-industrial complex in Ukraine should include methods that will ensure a sufficient level of solvency, ensuring their liquidity and profitability, thanks to a sufficiently high level of application of innovations, IT technologies, scientific and technical developments. After all, the financing of innovation and investment projects should become a powerful stimulator of the introduction of innovations in the agro-industrial complex of Ukraine, which will allow to stabilize and transform it into a strategic and competitive sector of the economy and increase the level of GDP.

In our opinion, among the possible financial resources to ensure the investment and innovation development of the agro-industrial complex, it is necessary to select the optimal option for financing and the cost of investment resources, which will take into account the provision of preferential financial opportunities for innovative areas of activity of agricultural enterprises and their development, taking into account the ecological and economic effect of their implementation. It is necessary to propose the use of grant resources for the development of the agrarian sphere, as an important tool for the development of the agrarian sphere and the implementation of business plans of micro, small and medium-sized enterprises of the agro-industrial complex (Table 1).

Table 1. Main performance indicators of enterprise the agro-industrial complex of Ukraine for 2020-2023 [3,6].

Features	2020	2021	2022	2023	mean	median	SD	Actual Deviation	Absolute deviation
Number of operating agricultural enterprises, pcs.	47340.0	51800.0	35600.0	32452.0	41798.0	41470.0	9246.9	-14888.0	-31.45
Property, plant and equipment, UAH mln.	540463.0	595909.0	486400.0	NaN	540924.0	540463.0	54756.0	-54063.0	-10.00
Agricultural production, UAH mln.	612121.5	712566.3	534380.3	558000.0	604267.0	585060.8	79194.3	-54121.5	-8.84
Crop production, UAH mln.	473377.0	580267.7	417907.6	474000.0	486388.1	473688.5	67886.5	623.0	0.13
Livestock products, UAH mln.	138744.5	132298.6	116472.7	114000.0	125379.0	124385.7	12046.0	-24744.5	-17.83

Note: NaN - missing data.

The trends described above can be seen using statistical data. Although their duration is limited to the period since independence, and often shorter, they can reveal some trends characteristic of Ukraine The current situation. First of all, it is worth considering separate indicators characterizing both livestock and crop production in natural terms. They are shown in Figure 1.

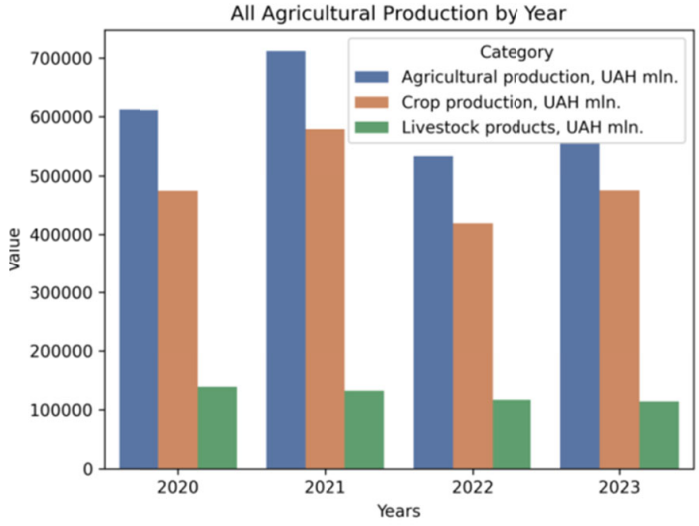

Fig. 1. Distribution of performance indicators of enterprises the agro-industrial complex of Ukraine for 2020-2023 [3, 7].

According to the data in Table 1, the number of operating enterprises the agro-industrial complex during the analyzed period decreased from 47,340 to 32,452, or by 31.45%. Among the main reasons, it should be noted, disruption of logistics, loss of markets for agricultural products, blocking of sea ports, deterioration of payment discipline, occupation or destruction of the capacity of enterprises of the agro-industrial complex.

Regarding the fixed assets of enterprises the agro-industrial complex during the analyzed period, there is a tendency to decrease by UAH 54,063 million, or by 10%, due to military actions in Ukraine, in particular, partial (or complete) destruction of agricultural objects, energy nodes, production workshops was recorded processing industry, agricultural machinery.

On the contrary, the volume of crop production increased by 623 million hryvnias, or by 0.13% for 2020-2023. This is due to the signing of the grain agreement in 2022, which created procedures for the safe export of grain from certain ports in order to solve the 2022 food crisis.

As for livestock production, a decrease of UAH 24,744.5 million, or 17.83%, was recorded due to the destruction of cattle, poultry and pig breeding.

The figure (all agricultural production by year) is a time series graph showing the total agricultural production (UAH million) in Ukraine from 2020 to 2023. It also shows the crop production and livestock production for the same years. Here are some observations based on the graph:

- Total agricultural production has fluctuated over the four years. It reached a high of nearly 720 million UAH in 2021 and a low of around 535 million UAH in 2022.
- Crop production seems to follow a similar pattern to total agricultural production, with a high in 2021 and a low in 2022.
- Livestock production appears to be more stable than the other two categories, with a slight decrease from 2020 to 2023.

The Figure 2 (heatmap) is a correlation heatmap of agricultural indicators in Ukraine.

Fig. 2. Correlation heat map of agricultural indicators in Ukraine for 2020-2023.

The heatmap shows the correlation between six indicators:

- Years.
- Number of operating agricultural enterprises (pcs.).
- Property, plant, and equipment (UAH mln.).
- Agricultural production (UAH mln.).
- Crop production (UAH mln.).
- Livestock products (UAH mln.).

The correlation coefficient is represented by a color scale. The stronger the correlation, the more intense the (doi.org) color. The values along the diagonal are all 1.00, which indicates a perfect positive correlation between a variable and itself.

Here are some observations based on the heatmap:

- The number of operating agricultural enterprises positively correlates with agricultural production, crop production, and livestock production. This suggests that as the number of enterprises increases, so does the overall production of agricultural goods.
- Property, plant, and equipment also has a positive correlation with agricultural production, crop production, and livestock production. This suggests that greater investment in infrastructure and equipment is associated with higher production levels.
- Crop production and livestock production are positively correlated with each other. This means that when crop production is high, livestock production also tends to be high, and vice versa.
- There is a weak negative correlation between the years and the number of agricultural enterprises, property, plant, and equipment, and (FAO.org) agricultural production. This could be due to a number of factors, such as economic fluctuations or changes in government policies.

It is important to note that correlation does not imply causation. Just because two variables are correlated does not mean that one variable causes the other. There could be a third factor that is causing both variables to change.

Here are some additional questions which might consider to further analyze the data:

- What factors might be driving the increase in the number of operating agricultural enterprises?

- How does investment in property, plant, and equipment lead to higher agricultural production?
- Are there specific crops or livestock products that are driving the correlation between crop production and livestock production?
- How can the negative correlation between the years and the other indicators be explained?

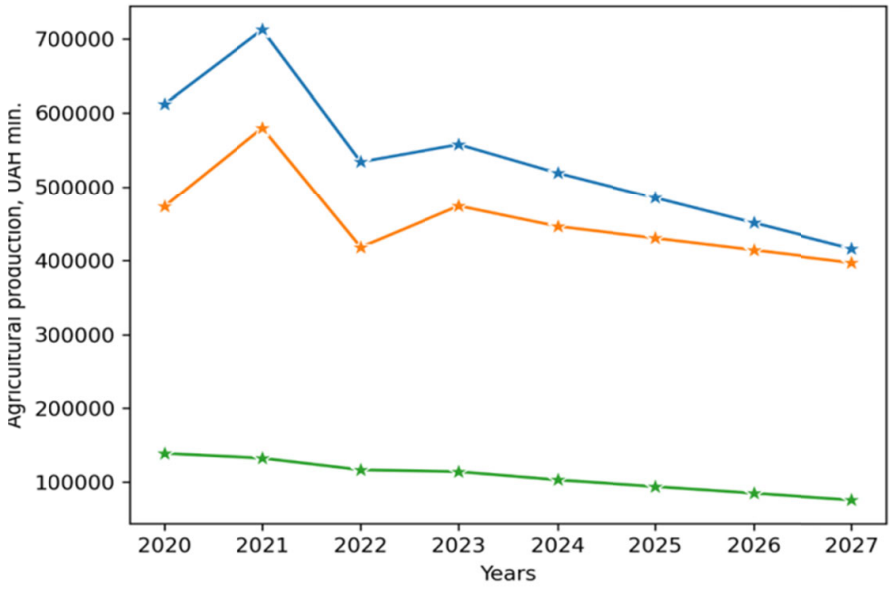

Fig. 3. The predicted values of three agricultural indicators in Ukraine from 2020 to 2027

The figure (prediction) is a line graph showing the predicted values of three agricultural indicators in Ukraine from 2020 to 2027. The indicators are:

- Agricultural production (UAH million).
- Crop production (UAH million).
- Livestock products (UAH million).

The x-axis shows the years, and the y-axis shows the predicted value of the indicator in millions of Ukrainian hryvnia (UAH). The graph shows a linear trendline for each indicator, extrapolating the data points from 2020 to 2023 to predict the values for 2024 to 2027.

Here are some observations based on the graph:

- The predicted values show a continuous increase in all three indicators over the next four years. This is a straight-line extrapolation, and assumes the current trends will continue. This may not be realistic, as external factors can significantly affect agricultural production.
- Crop production is predicted to have the most significant increase, followed by agricultural production and then livestock production. However, it is important to consider that these predictions are based on a limited dataset (four years) and may not account for factors that could specifically affect crop production more than the others.
- Linear trends may not always be the best fit for real-world data, especially for biological or economic data which can have cycles or plateaus.

Here are some additional factors to consider when interpreting these predictions:

- Weather patterns: Weather can significantly impact agricultural production. Droughts, floods, and other extreme weather events can all reduce crop yields and livestock production.

- Global commodity prices: The prices of agricultural products on the world market can affect how much farmers are willing to produce. If prices are high, farmers may be more likely to increase production.
- Government policies: Government policies, such as subsidies and import tariffs, can also affect agricultural production.
- The war in Ukraine: The ongoing war in Ukraine has had (acgs.uva.nl) a significant impact on agricultural production in the (lei.lt) country. It is difficult to predict how the war will continue to affect production in the coming years.

Because of these factors, the actual values of agricultural production, crop production, and livestock production in Ukraine from 2024 to 2027 may be higher or lower than the values predicted in the graph.

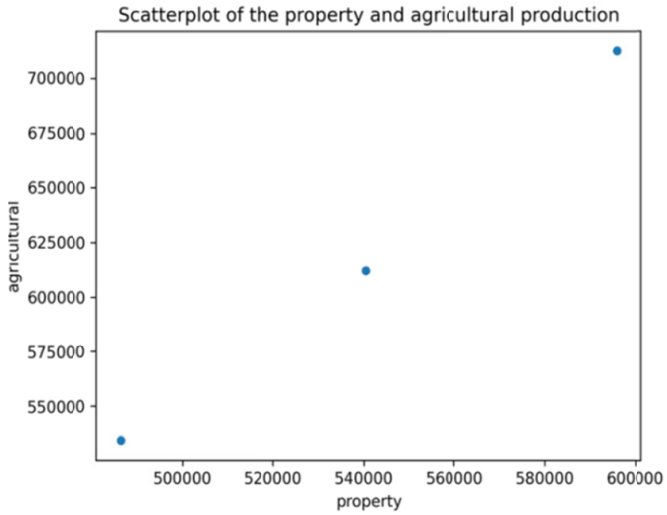

Fig. 4. The ratio between fixed assets (million hryvnias) and agricultural production (million hryvnias) in Ukraine for 2020–2022.

The scatter diagram in Figure 4 shows the ratio between fixed assets (million UAH) and agricultural production (million UAH) in Ukraine for 2020–2022. Each data point represents the values for one year. There appears to be a positive correlation between the two variables. This means that as the property, plant, and equipment increase, agricultural production also tends to increase. Here's a more scientific interpretation of the scatterplot:

- The positive correlation suggests that greater investment in infrastructure and equipment is associated with higher levels of agricultural production. There are a few reasons why this might be the case.
- Better equipment could allow farmers to cultivate more land more efficiently, potentially leading to higher crop yields.
- Improved infrastructure, such as storage facilities, could help farmers reduce spoilage and waste after harvest, thereby increasing the amount of product that reaches the market.

The scatterplot showing the relationship between property, plant, and equipment (UAH million) and agricultural production (UAH million) in Ukraine for the years 2020 to 2022.

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- Improved infrastructure, such as storage facilities, could help farmers reduce spoilage and waste after harvest, thereby increasing the amount of product that reaches the market.

The main emphasis of state support in Ukraine is financing the development of small and medium-sized agricultural producers, as well as industries that require special attention from the state: animal husbandry, horticulture, processing of agricultural products and agricultural machinery. The main areas of state support for financing enterprises of the agro-industrial complex in Ukraine are: plant breeding, livestock breeding, reclamation, grants for business creation, compensation for the cost of agricultural machinery and equipment of Ukrainian production (25% of the cost), support for organic production, cheaper loans, compensation for agricultural machinery (including foreign production), financial support for producers of organic production, compensation for the costs of demining agricultural land, gardening, support for farming [8; 9].

The amount of state support for the industrial complex increased from UAH 4,567.65 million in 2019 to UAH 8,000.0 million in 2022 [10;11]. Compensation for Ukrainian-made agricultural machinery increased from UAH 838.42 million in 2019 to UAH 991.36 million. in 2021. This is the way to economic growth of Ukraine. State support in the form of a budget subsidy is provided to enterprises of the agro-industrial complex for the reconstruction of existing fixed assets and/or those related to the construction of newly created systems and reclamation systems already put into operation. In 2021, the subsidy was equal to UAH 16.75 million, or 0.36%.

Budget funds for state support of horticulture increased from UAH 397.89 million, or 8.71% in 2019 to UAH 512.23 million, or 10.87%. Budgetary funds were directed to the repayment of accounts payable of enterprise's the agro-industrial complex, the purchase of planting materials for horticulture, with the installation of a drip irrigation system, the purchase of technical means with equipment (possibly foreign), which are related to the implementation of technological operations in horticulture. Figure 5 shows the feasibility of a more detailed study of the support program #1, 2, 3 and 7.

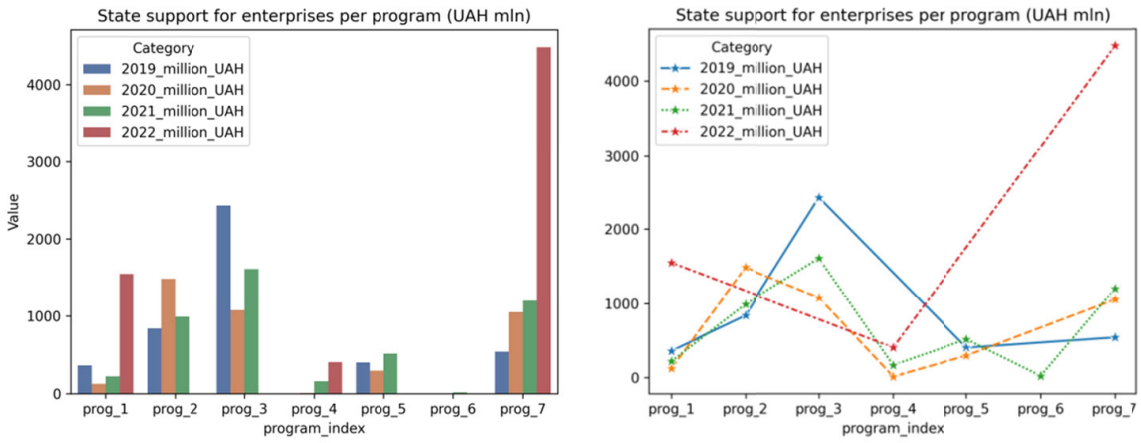

Fig. 5. State support of enterprises of the agro-industrial complex of Ukraine 2019 – 2022.

Figure 6 shows the number of recipients for the period 2019-2022, which decreased from 4,559 to 3,500 enterprises, respectively. The main reason for the increase in the amount of state support was the extension of the terms of the State Program "Affordable Loans 5-7-9%" to medium-sized enterprises with an annual income of up to 50 million euros and to large enterprises with an annual income of more than 50 million euros, regardless of the number of employees [12].

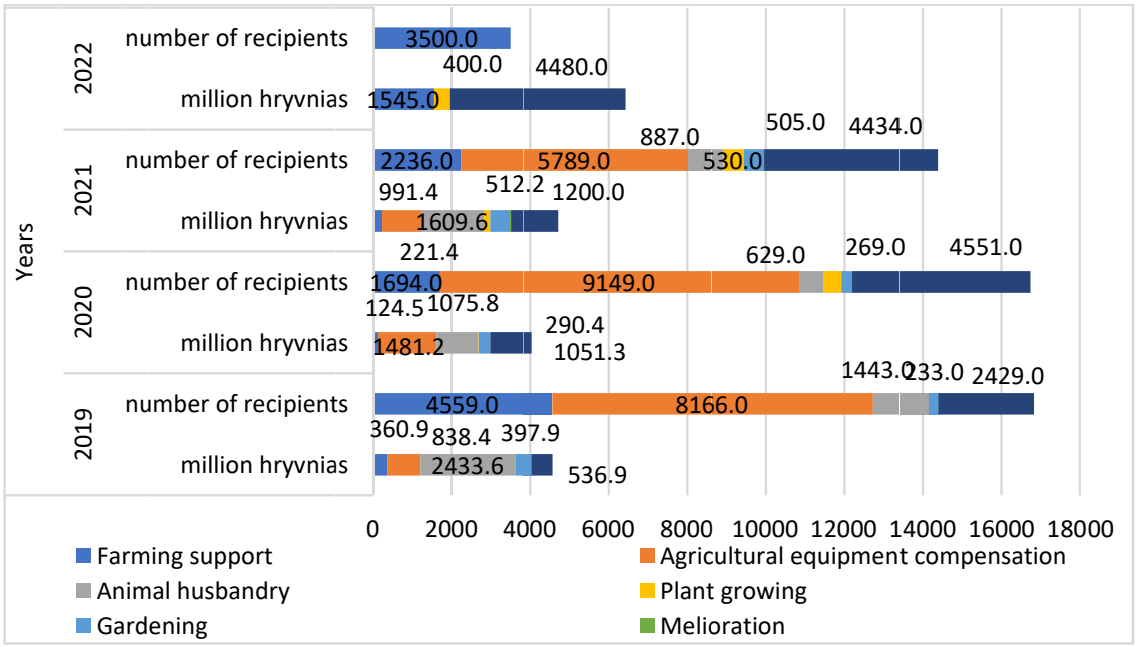

Fig. 6. Distribution of financial resources according to the main directions of state support of the agro-industrial complex of Ukraine in 2019-2022 [10, 11].

State program "Available loans 5-7-9%" - one of the types of investment lending aimed at the purchase of agricultural machinery, replenishment of working capital for the purchase of seeds, fertilizers and fuel and lubricants. At the same time, the interest rate is equal to 0% per annum, the difference between the preferential rate (5, 7 or 9%, later 0 or 3%) and the market rate is compensated from the state budget, but the decision to issue a loan is made by banks (Figure 7).

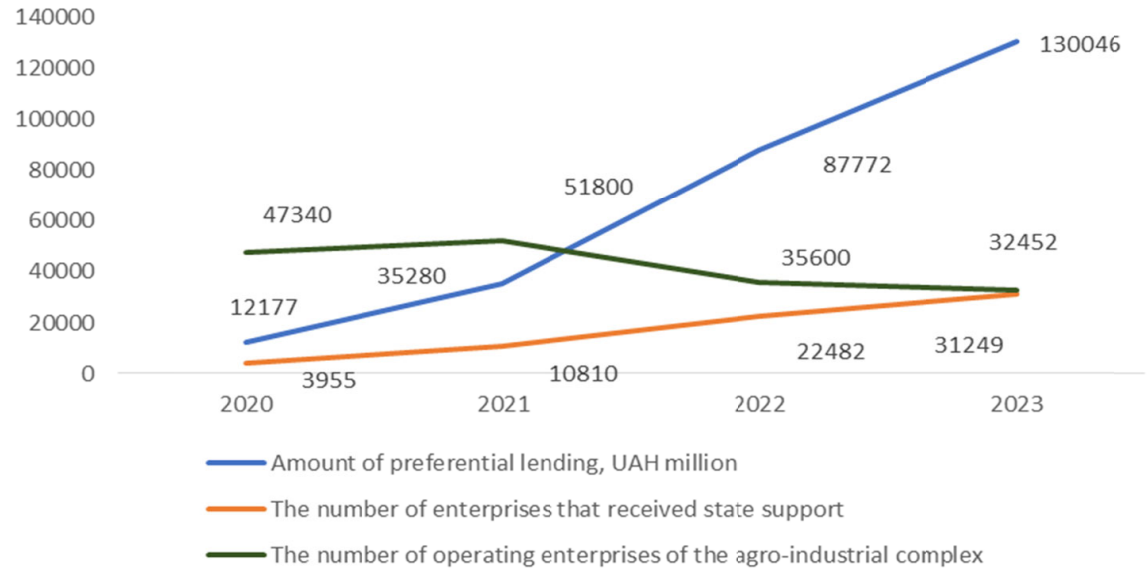

Fig. 7. Dynamics of the credit portfolio for the agro-industrial complex under the "5-7-9% Available Loans" program in Ukraine for 2020-2023 [3, 7].

Figure 7 shows the dynamics of the credit portfolio of the agricultural sector under the "5-7-9% Available Loans" program from 2020 to 2023. The number of enterprises that received state support under the "5-7-9% Affordable Loans" program increased from 3,955 enterprises in 2020 to 31,249 enterprises in 2023, that is, by 27,294 enterprises.

However, the number of active enterprises of the agro-industrial complex for 2020-2023 decreased from 47,340 to 32,452, respectively, that is, by 14,888 enterprises. Therefore, enterprises of the agro-industrial complex will become more subsidized in 2023.

Analysis of the data in Table 2 shows that the strategic priorities of the development for modern information, communication technologies, and robotics also require state support. This will contribute to the development of economic stability and resistance to agricultural crises. The use of an unmanned field demining complex to overcome the consequences of military operations. The unmanned demining complex includes: a drone, a demining robot, an autopilot and a towed tractor system capable of withstanding an explosion.

Table 2. Implementation of innovative products (services) in the agro-industrial complex of Ukraine for 2021-2022, UAH million [13]

Strategic priority	Volume of realized innovative products (services), everything		Including			
			new for the market		outside Ukraine	
	2021	2022	2021	2022	2021	2022
Development of new energy transportation technologies, introduction of energy-efficient, resource-saving technologies, development of alternative energy sources /priority_1	19.22	12.97	18.45	12.08	0.77	0.89
Technological renewal and development of the agro-industrial complex /priority_2	208.14	154.67	59.76	41.47	-	0.79
Wide application of cleaner production and environmental protection technologies /priority_3	9.13	5.13	4.44	4.54	-	0.59
Development of modern information, communication technologies, robotics /priority_4	15.85	12.23	15.44	10.54	0.01	0.69
Total	252.34	185.00	98.09	68.63	0.78	2.96

The structure of innovative products (services) of the agro-industrial complex of Ukraine in terms of priority directions in Ukraine for 2021-2022 shown in the Fig. **8.**

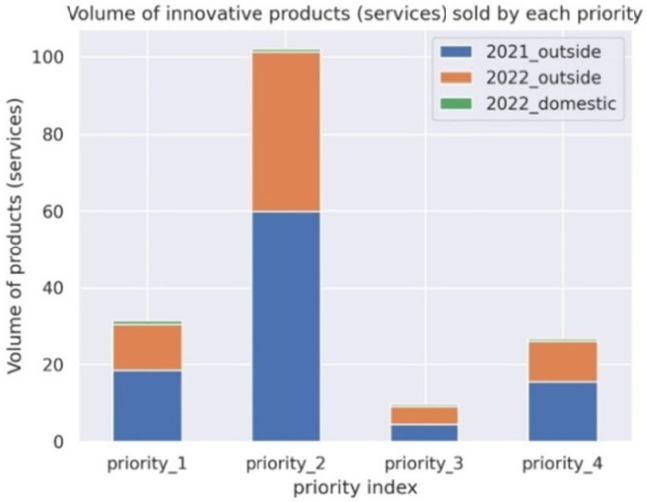

Fig. 8. The structure of innovative products (services) of the agro-industrial complex of Ukraine in terms of priority directions in Ukraine for 2021-2022, %.

Among the priority areas of innovation and investment development of the agro-industrial complex in Ukraine for the post-war period should be: digital farming, robotics and automated equipment for sustainable crop production, reduction of ammonia emissions in agriculture, primarily in the territory of Donetsk, Zaporizhzhia, Mykolaiv, Kharkiv and Kherson regions on which hostilities or temporarily occupied territories are being conducted.

4 Conclusions

Summarizing the issue of diversification of sources of financing of innovation and investment projects of the agro-industrial complex of Ukraine, the following conclusions were drawn:

1. Military operations and the economic crisis caused a general drop in Ukraine's agro-industrial complex production volume by almost 31.45% in the period 2020-2023.

2. It requires further research with an expert assessment of all areas for the activity of the agro-industrial complex in the post-war period, which requires the determination of the diversification of sources of financial resources using project approaches and the introduction of the latest innovative technologies to ensure the reduction of negative impacts on climate change and the greening of agricultural production, diversification of possible risks obtaining financial resources.

3. The forecast made with the help of a scatter diagram and a linear diagram from 2024 to 2027 showed the need to increase the financing of the investment and innovation component, in particular, support for the provision of services for digitalization's agriculture and automation's processes to develop modern information, communication technologies, robotics and the comprehensive implementation of innovative technologies environmentally friendly production. First, better equipment could allow agro-industrial enterprises to cultivate land more efficiently and contribute to higher yields. Secondly, partial compensation for the purchase of agricultural machinery by the Ukrainian manufacturer will allow the double share of domestic agricultural machinery in the domestic market of Ukraine, including creating additional jobs. This, in turn, will lead to an increase in taxes on the state budget of Ukraine, the development of the agricultural and industrial sectors and the economy as a whole.

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