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SCIENTIFIC BASES OF INVESTMENT DEVELOPMENT AND CAPITAL RENEWAL OF THE AGRICULTURAL SECTOR OF UKRAINE

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ABSTRACT

Investments in modern material and technical equipment are key factors in the sustainable development of the agricultural sector, contributing to increased production, higher labour productivity, and greater food security. Modernising agriculture by upgrading fixed assets ensures more efficient use of resources, higher returns on capital, and lower production costs. The Ukrainian agricultural sector has suffered significant losses during the war: reduced investment, destruction of production infrastructure, complications in the logistics of supplying equipment, and reduced access to financial resources.

The purpose of the article is to analyse the current state of material and technical support for agricultural production, identify the main trends in its development, and develop proposals for restoring investment activity and technical potential in the industry.

Monographic, comparative, analytical, tabular, graphical, and abstract-logical methods are used in the study. It was established that the processes of reforming agricultural enterprises caused crisis phenomena in the formation of their technical base, which negatively affected the provision of production with fixed assets. The analysis showed a close connection between investment activity, technical equipment, and the level of capital efficiency.

The study revealed a downward trend in the efficiency of fixed assets and capital investments in the long term. At the same time, the reduction in the number of machines is not a sign of decline, but rather indicates an increase in the productivity of existing machines and problems in domestic machine building, which do not meet the needs of the agricultural sector.

Proposals have been made for improving technical support for agriculture, including innovative development, upgrading technical and technological infrastructure, stimulating investment activity, and strengthening state support to ensure the sustainable development of agricultural production.

Keywords: fixed production assets, capital equipment, agricultural machinery, efficiency, gross value added, capital investment, state support

JEL Classification: Q14, Q16, E22, O13

INTRODUCTION

Agriculture is a systemically important industry. Its special merit lies in ensuring human life and forming the foundations of food security in each country. Considering the current state of global trends and challenges, agriculture needs to modernise the current system of productive forces and production relations – improve, update, and bring them in line with innovative requirements and standards.

A key role in the development and economic efficiency of agriculture is played by the presence and combination of structural elements of capital – land, means and objects of labour, labour resources, and entrepreneurship. Its scale and efficiency of using the resource base are determined by the material and technical base of agricultural production, the main component of which is the main production facilities, especially their active part, machinery and equipment. Their qualitative composition and structure, the level of capital equipment of agricultural land and labour capital equipment, dramatically

affect the economic results of economic activity, the development of rural areas, and the agricultural sector as a whole. The current quantitative and qualitative characteristics of fixed capital in agricultural enterprises of Ukraine do not strengthen the significant competitive positions of Ukrainian farmers, especially medium and small forms of management.

Based on the current state, global trends, and challenges, the agricultural sector of the economy needs to update its resources and facilities, especially its active part-machines and equipment, and introduce innovative solutions in technical and technological support in accordance with the requirements of the time.

LITERATURE REVIEW

Ukrainian and foreign researchers played a significant role in the investigation of the state of technical and technological support for agricultural production, the development of the market of material and technical resources, the efficiency of their use, and renewal in agricultural enterprises.

Marie Vander Donck, Philip Chan · Andrea Silvestrini (2021) emphasised the need to evaluate the fixed capital operating in agriculture to determine the contribution of this factor to the production of gross output. Researchers assessed its productivity, the relationship between fixed assets and gross output, capital investments and gross value added, and considered the main global and regional trends in gross fixed capital accumulation in agriculture. Analysing the capital availability of agricultural production, the researchers concluded that the growth of productivity in agriculture frees up resources for other sectors of the economy, creating the basis for successful industrialisation.

Yared Deribe Tefera, Bisrat G. Awoke · Thomas Daum (2025) continued the theme of fixed production assets, but paid special attention to their active part – agricultural machinery. They proved the importance of machinery and technologies for the development of agriculture and improving the living conditions of rural residents. The researchers made proposals regarding the inclusivity of mechanisation and innovative technologies in the agricultural sector. They also considered the relationship of technical and technological support with the effectiveness of production activities in agriculture, in particular, with gross production and labour productivity. They analysed how financial results from conducting economic activities (their own sources of investment resources) affect the renewal of the technical and technological base of agriculture.

Tamrat Gebiso, Mengistuetema, Arega Shumetie Getachew Leggesse (2023) also argued the need to expand the technical and technological base in agricultural production. Their study presented the results of assessing the level of mechanisation of farms and its determinants. After conducting a survey and analysing the data obtained using the Tobin model, the researchers came to the conclusion that the effectiveness of economic activity is influenced, in addition to general factors, by the distance to the centres for providing agricultural mechanisation services, participation in market and non-farm activities, and the size of agricultural land owned.

Jeetendra Prakash Aryal, Dil Bahadur Rahut, Sofina Maharjan · Olaf Erenstein (2019), using a multidimensional profit model, calculated the interdependence of the use of machine types and proved that the probability of purchasing them directly depends on the economic situation of farmers, market access, and participation in non-farm activities. They proved that owning machinery is not mandatory for its use, as most farmers hire these services. The main results of the national policy were to facilitate access to and use of agricultural machinery by creating conditions for the development of small machinery and rental services, and to increase farmers' incomes through access to markets, knowledge, and income opportunities outside of farms.

Analysis of mechanisms shows that public investment in agriculture not only increases agricultural productivity by increasing the number of agricultural machines, but also by encouraging large-scale agricultural operations. Therefore, increasing public investment in agriculture is crucial for increasing agricultural productivity, say Siqi Zhang, Rong Cai · Shujuan Wang (2025). They proved that public investment in agriculture not only increases agricultural productivity by increasing the number of agricultural machinery and encouraging large-scale agricultural operations, but is also crucial for increasing agricultural productivity. This practice deserves to be followed by developing countries.

Empirical data from Karel Malec et al. (2024) proved that the extraordinary increase in agricultural productivity is mainly due to genetic modernisation and new varieties of agricultural crops. Despite this, technological progress in agriculture cannot be achieved without appropriate investment in agricultural technical and technological innovations. They provide a high positive return. Any lack of investment in this regard can hinder long-term agricultural productivity, poverty reduction, and the ability to develop strong value chains in food and non-food products.

Using the autoregressive distributed lag cointegration method to measure the short-term dynamics and long-term relationship between foreign direct investment in agriculture and the share of agriculture in GDP, Mohammad Chhiddikur

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Rahman et al. (2024) studied their impact on the importance of the agro-industrial complex in the country's economic development. The results of the assessment confirmed that foreign direct investment in agriculture has a statistically significant impact on the efficiency of agricultural production in the short term; in the long term, it was insignificant. Therefore, it was proposed to improve the policy of creating a "favourable investment climate" to attract foreign investment in the agricultural sector to increase its productivity.

L.G. Nabieva, L.M. Davletshina (2015) in the paper "Return on Investments in the Formation of Fixed Capital Assets in Agriculture of the Republic of Tatarstan" analysed the effectiveness of investments in fixed assets of agriculture. The study focused on assessing the return on investment in the agricultural sector, considering statistical data on investment and investment attractiveness of the industry.

All the issues considered by researchers helped to investigate in detail the issues of investment and resources and facilities in agriculture, and offered effective ways to solve the problems under study. The purpose of this study was a comprehensive analysis of the level of technical, technological, and investment support for agricultural production, the development of ways to improve the efficiency of using the technical base, and the formulation of practical proposals aimed at overcoming the negative consequences of the impact of war on investment and material and technical support for agricultural production.

AIMS AND OBJECTIVES

The aim of the study is to conduct a comprehensive analysis of the state of material and technical support for agricultural production in Ukraine, assess the main trends and parameters of reproduction of fixed assets, identify factors that hinder capital renewal in conditions of military conflict, and develop practical proposals for increasing investment activity and restoring the technical and technological base of the industry.

To achieve the set goal, the following key tasks were identified and performed in the study:

1. Conduct a comprehensive analysis of the current state, trends, and prospects of the technical development of agricultural enterprises, including the identification of key problems and systemic obstacles.
2. Assess the dynamics of capital investments in agriculture by source of funding and determine changes in their intensity in the pre-war and war periods.
3. Compare Ukraine's level of capital adequacy and investment intensity with leading EU countries (identify gaps and their determinants).
4. Investigate the direct and indirect impact of military actions on the technical and financial support of the agro-industrial complex, and develop ways for its effective recovery and stabilisation.
5. Identify priority areas for technical modernisation of the agricultural sector, based on the introduction of innovative and environmentally friendly technologies.
6. Formulate scientifically sound recommendations for state authorities and management bodies with a view to optimising the mechanisms of state regulation of technical support for agricultural production.

METHODS

To investigate the state, development, and efficiency of using the resources and facilities in agriculture, methodological approaches inherent in both the planned economy and advanced research were used.

In general, there were two main approaches to assessing the level of technical security of agricultural enterprises: determining the actual level, which was based on the absolute indicators of available machinery and equipment; determining compliance with standards**,** the assessment was based on a comparison of available technical resources with established regulatory indicators.

Capacity assessment was carried out by calculating the total technical resources available to agricultural enterprises. For this purpose, various methods of comparing production resources were used, including: determining the monetary value of all elements of resource potential; evaluating technical resources in physical units of measurement, calculating the number and cost of resources per unit area of agricultural land, etc.

The calculation of the standard demand for fixed assets was based on target performance indicators, for example, the volume of production of a particular type of product, the level of yield, or the average milk yield. This method is provided for establishing the standard value of the necessary means of production and its subsequent comparison with the actual achieved value.

To assess the level of technical equipment of the agricultural sector and the efficiency of using the components of the resources and facilities, a set of indicators was developed, which included: data on the availability and technical condition of fixed production facilities in agriculture; indicators of investment in the agricultural sector and the purchase of various types of agricultural machinery; the number of equipment and capacities in agriculture in natural units (tractors, combine harvesters, ploughs, cultivators, harrows, seeders); the movement of equipment in the agricultural sector; and indicators of the efficiency of using fixed capital and the level of equipment of agriculture with labour.

Changes in the absolute and relative sizes of fixed production facilities for various purposes, including technical ones, and their species composition and structure over several years were analysed. The average annual growth and growth rates were determined, which helped to establish key trends and their dynamics. This determined the rational structure and size of funds that contribute to improving the indicators of economic activity.

The resource intensity indicators calculated in this study reflected the amount of consumption of a certain type of material and technical resources required to achieve a unit of useful effect from production.

In the conditions of contemporary management, ensuring a structural balance of resource potential becomes particularly relevant. This involves analysing the ratio of individual components of resource potential in value terms. Imbalances in the structure of resources lead to a decrease in the efficiency of agricultural production in farms.

The conducted research allowed for an analysis in more detail of changes in absolute and relative values of fixed production assets, including technical resources. The analysis covered their species diversity and structure over several years, average annual growth and growth rates, which allowed identifying the most significant trends in dynamics, and determining their optimal structure and volumes that contribute to improving economic performance.

In addition, these indicators established key relationships between factors and performance indicators, in particular, between the level of capital equipment of land area, labour capital, technical equipment, the ratio of fixed and working capital, and other indicators. They also helped to assess the effectiveness of the use of the material and technical base, identify ways and form recommendations for improving its structure and ensuring more efficient use.

RESULTS

For the successful development and efficient operation of agricultural enterprises, it is extremely important to provide them with the necessary resources, equipment, and investments. This allows increasing the volume of agricultural production and significantly expanding the production capacity of enterprises. As a result, the overall performance of the industry increases, which, in turn, contributes to strengthening the country's food security. Investments, especially those aimed at introducing innovations in the resources and facilities, have a profound impact on economic activity, determining the trajectory of economic growth in general. The need to attract capital investments is conditioned by the need to restore and modernise the existing resources and facilities, expand production volumes, and develop new types of agricultural activities, which allows enterprises to remain competitive and adapt to changing market conditions.

Military operations significantly affected the investment and material and technical support of agricultural enterprises. The study identified the main problems that arose during this period (Table 1). They were classified into the following blocks: problems of state regulation, technical and technological, financial, and social and personnel issues.

As a result of the military operations, the investment climate in the agricultural sector has significantly worsened due to high risks and economic instability. Research conducted in collaboration with the Institute of Agrarian Economics showed that the war led to the destruction of many enterprises that produce agricultural machinery, complicated the supply of imported equipment due to logistics violations, and also caused significant losses of agricultural machinery and logistics facilities in the war zone and in the occupied territories.

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Table 1. Problems of attracting investment and updating the resources and facilities in agricultural production in Ukraine.

Problems of state regulation	Insufficient funding for state programmes to support agriculture, especially for small and medium-sized farmers, leads to their weak competitiveness. Factors such as limited compensation for the cost of domestic equipment, low level of leasing support, unfavourable product prices, war, and inflation exacerbate this problem.
	Imperfect internal tax policy (abolition of tax benefits, increased tax pressure).
	An imperfect customs policy contributes to higher prices for high-tech imported equipment.
Financial problems	Inaccessibility of agricultural enterprises to obtaining credit resources and leasing services (high interest rates, high requirements for the subject of lending.
	Rising prices for new agricultural machinery, which is unavailable due to a lack of funds, negatively affect the profitability of agriculture.
Technical and technological problems	Ukrainian agricultural engineering does not provide farmers with modern equipment; in particular, there is no production of high-tech samples and small-sized equipment, which hinders the development of the industry.
	Lack of a developed system of sharing equipment between agricultural service cooperatives.
Social and human resources issues	Due to the war in Ukraine and low wages, there is an acute shortage of qualified workers, especially workers with technical skills, such as machine operators.

The dynamics of agricultural capitalisation indicate an increase in the initial cost of fixed assets in this area. According to the State Statistics Service and the calculations, at the beginning of 2024, it amounted to approximately UAH 692.6 billion (USD 18.6 billion), which corresponds to almost 6% of the total cost of fixed assets in Ukraine (Table 2). In terms of UAH, this is 16.4% more than in 2021, but in USD, there is a decrease of 8.7% (Availability and movement of tangible assets.., n.d.).

Table 2. Projected demand for fixed assets for the agricultural sector until 2030 (subject to regulatory requirements), UAH billion.
(Source: calculated based on the data (State Statistics Service of Ukraine, n. d.))

Type of fixed assets	Fixed assets of agriculture measured at their initial cost		Regulatory demand for fixed assets by farm category					
			Agricultural enterprises		Households in rural areas		All categories of farms	
	Year							
	2024 (at the beginning of the year)		2025	2030	2025	2030	2025	2030
	actual	*calculated*						
Buildings, structures, and transmitting devices	272.5	749.4	896	1,159	314.8	386.4	1,210.8	1,545.4
Machinery and equipment	187.9	498	645.8	835.5	226.9	278.5	872.8	1,113.9
Vehicles	46.6	119.3	139.1	180	48.9	59.9	188	239.9
Productive cattle	40.8	42.6	97.2	125.8	34.2	42	131.4	167.7
Perennial plantings	11.2	13.5	19.9	25.7	7	8.6	27	34.3
Measuring instruments, inventory, tools, etc.	61.1	161.4	201	260	70.6	86.6	271.6	346.6
Total	692.6	1,584.2	1,999.1	2,585.9	702.4	861.9	2,701.4	3,447.8

The market fair value, according to our calculations, was approximately UAH 1.5-1.6 trillion at the beginning of 2024, or 2.3 times more.

The authors fully share the opinion of Kisil, M., Malik, M., & Shpykuliak, O. (2024) regarding planning the necessary fixed assets and investments aimed at their creation and modernisation. According to the researchers, the basis for determining the volume of capital investments should be the cost of investment projects implemented in the agricultural sector.

According to scientific research, the dynamics of fixed and working capital, gross value added, and the rate of profit in agriculture are closely related (Figure 1). The volume of fixed and working capital in agriculture has undergone significant changes: from USD 63.6 billion in 2013 to USD 74.4 billion in 2021. However, since the beginning of the war in Ukraine, there has been a significant reduction – up to USD 45.1 billion in 2023. Similarly, the rate of return, which rose from 5.2% to 16.8% and then fell to 12.2% in 2021, also fell significantly due to the war, reaching 5.8% in 2023.

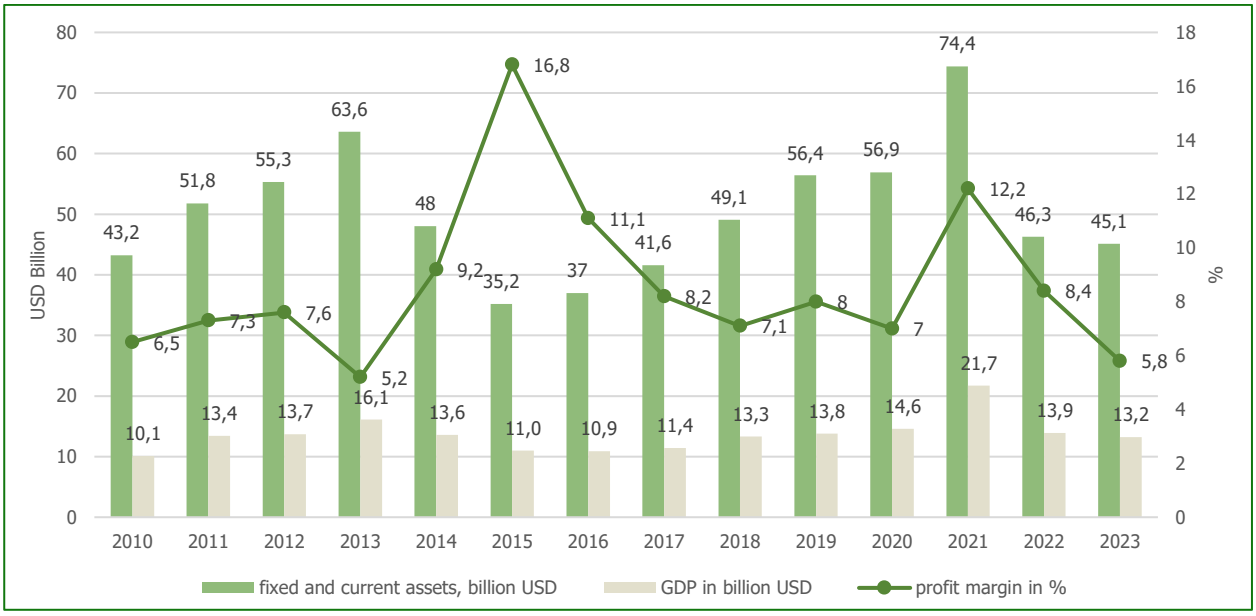

Figure 1. Changes in fixed and working capital indicators, and gross value added in agriculture in Ukraine (USD billions). *(Source: calculated based on the data from Statistical Yearbook of Ukraine (n.d.) and Availability and movement of tangible assets, (n.d.))*

The correlation and regression analysis revealed a strong relationship between the volume of fixed and working capital in agriculture and the generated gross value added (coefficient of determination 0.9) (Figure 2). This means that changes in the volume of these funds significantly affect the economic results of the industry. In addition, monitoring the dynamics of fixed and working capital and capital efficiency indicates that investors actively respond to market signals and strive to maximise the return on their investments.

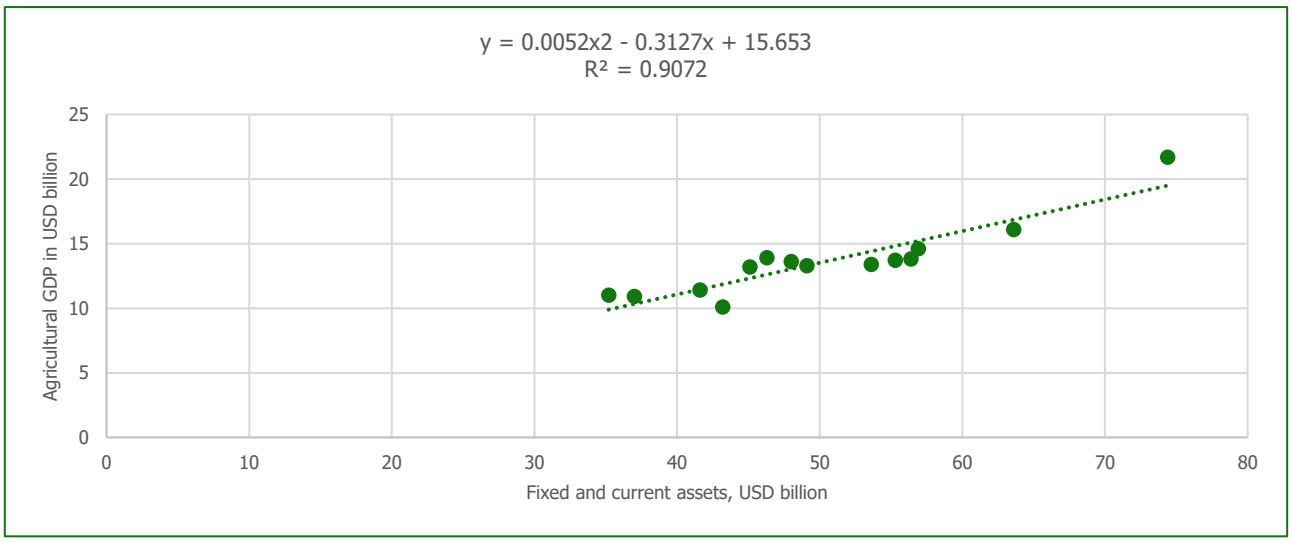

Figure 2. Dependence of agricultural GDP on its capital availability. *(Source: calculated based on the data from Statistical Yearbook of Ukraine (n.d.) and Availability and movement of tangible assets, (n.d.))*

From 2010 to 2023, agriculture in Ukraine was characterised by a positive trend: gross value added increased by 30.7%, and the cost of fixed assets of production increased by 32.9% (Table 3). However, these achievements were accompanied by a significant reduction: the average number of employees decreased by more than 40%, and the area of agricultural land decreased by 18%. These changes indicate possible shifts in the structure of production and resource use in the agricultural sector.

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Table 3. Trends in the use of fixed assets in agriculture in Ukraine. *(Source: Statistical Yearbook of Ukraine, n.d.; Agriculture of Ukraine, n.d.; Availability and movement of tangible assets by type of economic activity, n.d.)*

Indicator	Year							2023 to 2010, %	2023 to 2021, %
	2010	2015	2019	2020	2021	2022	2023		
Volume of gross value added created in agriculture, USD billion	10.1	11	13.8	14.6	21.7	13.9	13.2	130.7	60.8
Average number of employees in agricultural enterprises, thousand people	645.2	491.4	515.4	500.9	486.4	410.8	379.1	58.8	77.9
Land area in agricultural enterprises, million hectares	20.9	20.5	20.7	20.7	21.4	17.4	17.2	82.3	80.4
Cost of fixed assets of agriculture, USD billion	14	9.4	17.8	19.7	21.4	18.5	18.6	132.9	86.9

Compared to 2021, in 2023, capital intensity fell by 30.0%, and capital efficiency increased by 42.9%, which is a positive trend in the use of fixed capital in wartime conditions. During this period, the capital availability and capital security of agricultural enterprises increased slightly by 11.5% and 8.1%, respectively.

In the period from 2010 to 2023, agriculture in Ukraine showed a significant increase in its weight in the economy. Its share of gross value added, fixed assets, and capital investments increased (Figure 3). The most impressive growth was observed in the share of fixed assets (tripled) and capital investment (1.7 times). The increase in the share of gross value added was less pronounced, but still amounted to 21.4%.

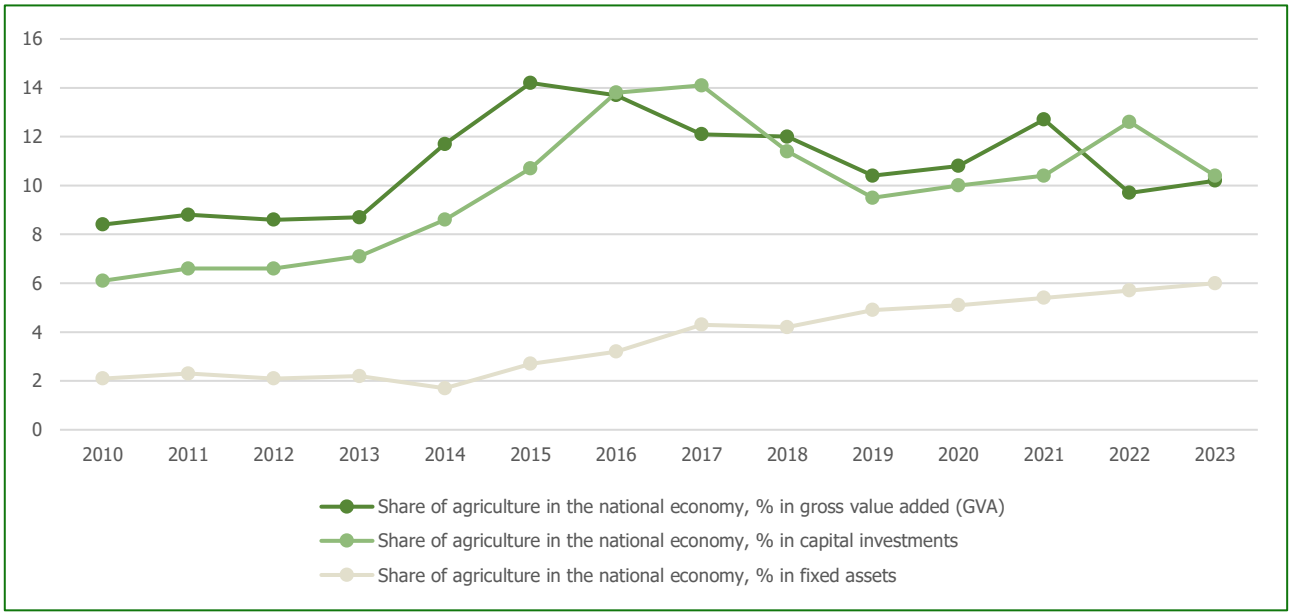

Figure 3. Share of agriculture in gross value added, fixed assets, and capital investments of the national economy of Ukraine in 2010-2023. *(Source: calculated based on the data from Statistical Yearbook of Ukraine (n.d.))*

The study of changes in the percentage of agriculture in gross value added (GVA), fixed assets, and capital investments in Ukraine from 2010 to 2023 (Figure 4) shows that, despite the increase in the GVA created by agriculture, the efficiency of using fixed production assets and investments in the agricultural sector has slightly decreased. In particular, there is a significant decrease in the following indicators: the ratio of the share of agriculture in the GVA to the share in capital investments decreased by 2.2 times; the ratio of the share of agriculture in capital investments to the share in fixed assets decreased by 1.7 times; the ratio of the share of agriculture in the GVA to the share in fixed assets decreased by 3.6 times. These trends indicate that investments and fixed assets in agriculture are used less efficiently compared to how they contribute to the creation of gross value added.

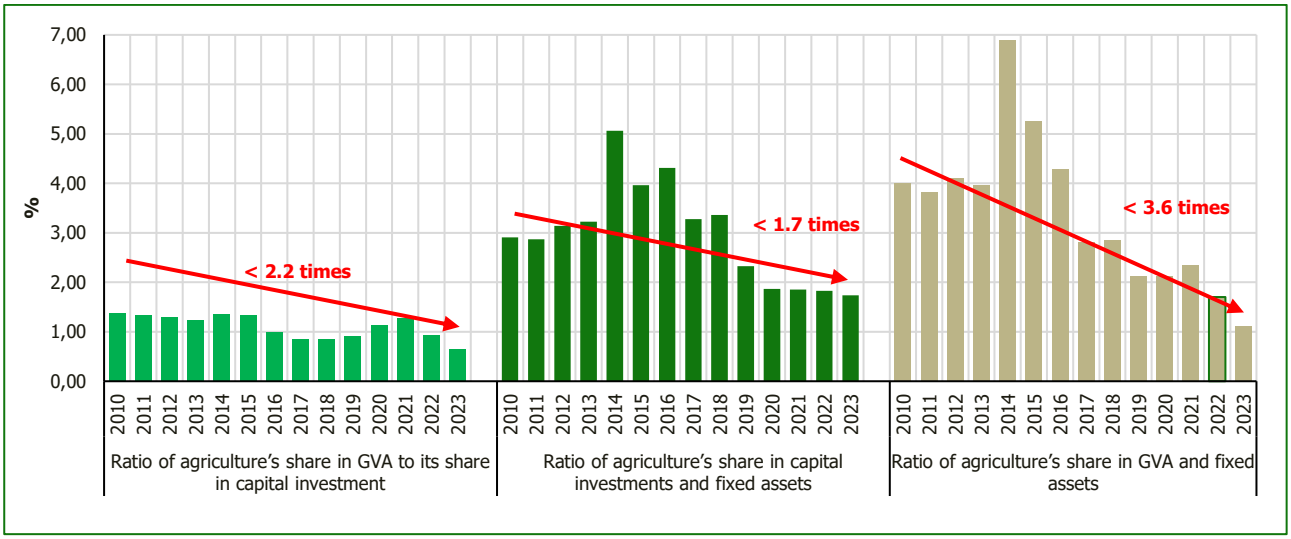

Figure 4. Dynamics of agricultural ratios in gross value added, fixed assets, and capital investments of the national economy of Ukraine in 2010-2023. *(Source: calculated based on the data from the Statistical Yearbook of Ukraine. (n.d.); Agriculture of Ukraine. (n.d.); Availability and movement of tangible assets by type of economic activity (n.d.))*

Despite the need for recovery and development, the agricultural sector of Ukraine in 2023 received only UAH 63.8 billion of investment (USD 1.7 billion). This is significantly less than in pre-war 2021, when the volume of investments amounted to UAH 68.0 billion (USD 2.5 billion). The drop in investment, which is almost a third in USD terms, indicates serious problems with financing the industry during the war. Instability of investment dynamics and insufficient investment volumes hinder the expanded development of agriculture, which has already experienced three investment crises over the past 10 years (in 2015, 2020, and 2022) (Figure 5).

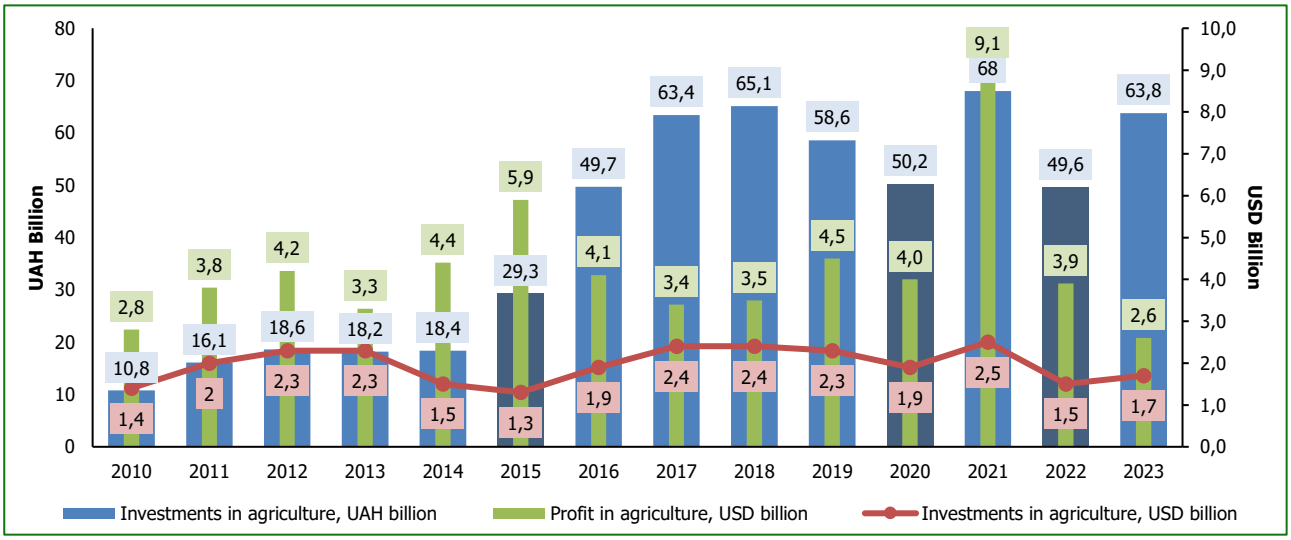

Figure 5. Trends in capital investment and returns in the agricultural sector during 2010-2023, presented in actual prices and in USD terms. *(Source: calculated based on the data from Statistical Yearbook of Ukraine, (n.d.); Capital investments by types of assets by types of economic activity, (n.d.); Official exchange rate of the UAH against foreign currencies (n.d.))*

In wartime conditions, businesses invest an average of only USD 95-110 per hectare of cultivated land. This is clearly not enough, because international experience shows that to ensure the sustainable development of agriculture, it is necessary to invest more than USD 150 per hectare (Zakharchuk, 2025).

Nowadays, more than 95.4% of all investments are made up of enterprises and organisations' own funds, while only 4.6% are made up of bank loans, and state participation is almost insignificant (Capital investments by sources of financing, n.d.). For the successful development of capital reproduction processes in the agricultural sector, it is important that the ratio of own and attracted funds for capital investments is approximately 2:1, as noted by M. Kisil (2018). He proved that a low share of attracted investments can hinder the reproduction of capital in agricultural producers, while their excess

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can increase the risk of insolvency. In wartime conditions, priority should be given to supporting and developing investment projects in small agribusiness.

The equipment of agriculture with the main production facilities in Ukraine is significantly inferior to that of the developed countries of Europe. While Ukrainian agriculture uses them in the amount of USD 17.9 billion, the leaders of the EU and the UK show much higher indicators: Germany – USD 200.7 billion, Italy – USD 169.2 billion, the UK – USD 138.0 billion (Figure 6). This difference indicates a significant lag in Ukraine in the level of technical support for the agricultural sector.

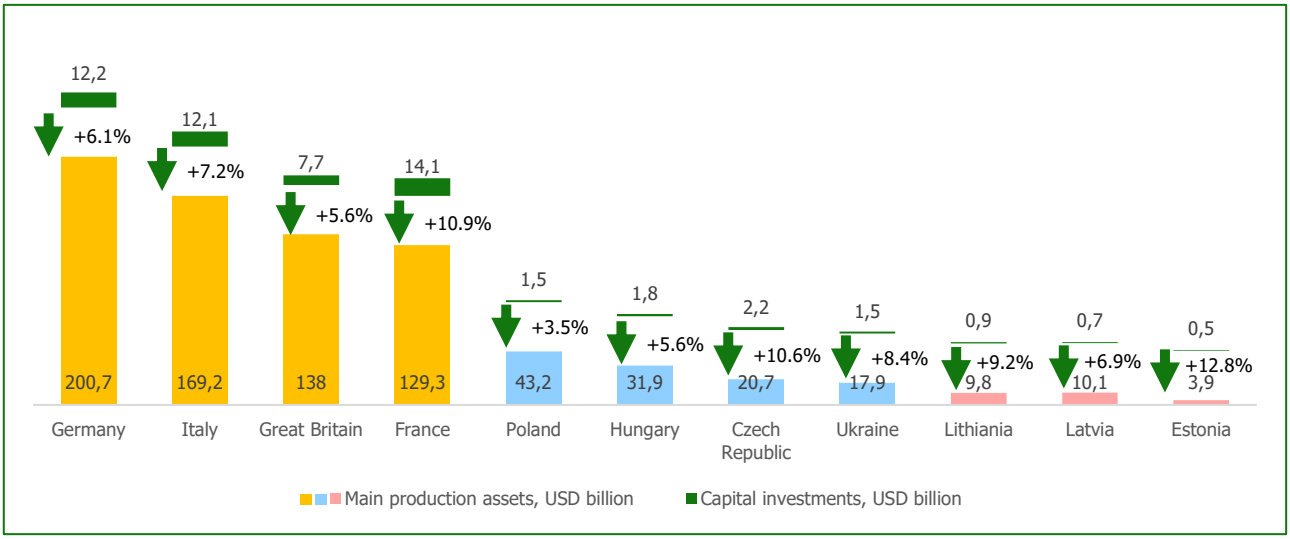

Figure 6. Fixed production assets and capital investments of agriculture in Ukraine, EU countries, and Great Britain, USD billion. *(Source: Gross fixed capital formation in agriculture, n.d.; Capital Stock, n.d.)*

During 2022-2023, Ukraine invested approximately USD 1.5-1.7 billion annually in fixed assets. This volume of investment is significantly lower than in most European Union countries. Investment activity in Ukraine has significantly decreased over the past decade due to a number of factors, in particular, the war, the COVID-19 pandemic, and the loss of territories, which led to a stop in the positive dynamics of investment development.

Every year, EU countries such as Germany and Italy invest USD 12.2 billion and USD 12.1 billion, respectively, in France – USD 14.1 billion. EU countries such as Lithuania, Latvia, and Estonia invest slightly less, respectively – USD 0.9, 0.7, and 0.5 billion (Gross fixed capital formation in agriculture, n.d.).

The analysis shows that the volume of capital investment in agriculture in Ukraine per unit area of agricultural land is the lowest in comparison with the UK and the European Union countries. In particular, in Ukraine, this figure is approximately USD 100 per hectare, while in Italy, Germany, and France it is USD 930, USD 735, and USD 498, respectively.

According to data (Table 4), the capital security of European countries is quite high compared to that of Ukraine. If in Ukraine it is USD 781.7 per 1 ha, then in Italy – USD 13,015, Germany – USD 12,094, UK – USD 8,193.

Table 4. Capital availability of agriculture in the EU, Great Britain, and Ukraine, USD/ha. *(Source: calculated based on the data from Capital Stock, (n.d.); Arable Land by Country, 2025)*

Country	USD/ha	Relative capital security index by country (Ukraine=1)
Italy	13,014.6	20.4
Germany	12,094.0	18.9
Hungary	6,284.5	9.8
Czech Republic	5,863.4	9.2
United Kingdom	8,192.9	12.8
Latvia	5,126.9	8.0
France	4,568.2	7.2
Estonia	3,955.4	6.2
Lithuania	3,366.2	5.3
Poland	3,047.4	4.8
Ukraine	781.7	1.0

The capital availability of agriculture per 1 hectare of agricultural land in Ukraine is significantly lower than in many European countries. In particular, in Italy, this figure is 20.4 times higher, in Germany, 18.9 times, in the UK, 12.8 times, and in Poland, 4.8 times.

One of the key indicators of effective use of the material and technical base is capital availability, which shows how much modern technologies, innovations, and best practices are involved in agricultural production. The leader in this indicator is Germany, where one employee accounts for fixed assets in the amount of USD 380.1 thousand. In France, Italy, and the United States, this figure is significantly lower and amounts to USD 174.3 thousand, USD 168.7 thousand, respectively. In Ukraine, the level of capital equipment lags significantly behind, amounting to only USD 43.6 thousand per employee (Gross fixed capital formation in agriculture, n.d.; Number of people employed in agriculture, 1801 to 2019, n.d.).

If capital intensity shows how much capital investment is needed or actually falls on the production of a unit of output, then the inverse indicator – capital return, characterises how much production is produced from each UAH of capital investment (Figure 7). The capital intensity of agricultural products in comparison with the EU countries and the UK is the highest in Ukraine, 1.30; in other countries, it is less than 1.0.

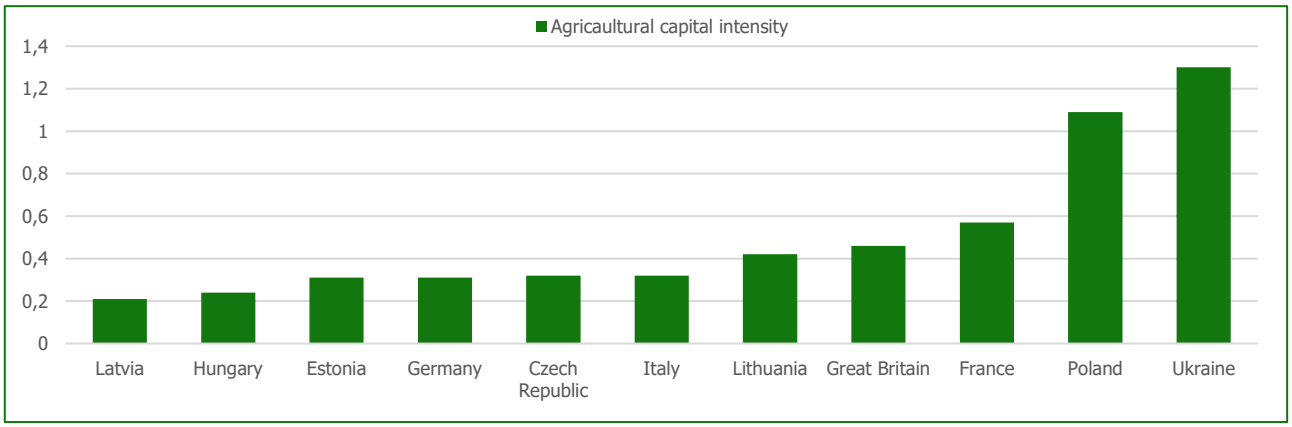

Figure 7. Comparison of agricultural capital intensity in Ukraine, EU countries, and the UK, USD/USD. *(Source: calculated based on the data from Performance of the agricultural sector, 2025; Capital Stock, n.d.)*

Capital return in Ukraine is the lowest in comparison with other EU and UK countries and amounts to 0.80. Latvia has the best capital return rate – almost 4.81.

Before 2022, the agricultural machinery market in Ukraine was characterised by a wide range of products presented by both domestic and foreign manufacturers. The range met the needs of various categories of agricultural producers, considering their technological requirements, financial capabilities, and other criteria. In 2024, compared to the pre-war period, there was a significant decrease in the volume of purchases of agricultural machinery by both agricultural enterprises and households. This was conditioned by the consequences of Russian aggression, in particular, the occupation of territories, loss of equipment, reduced profitability, and a shortage of working capital.

The assessment showed that in comparison with 2021, agricultural enterprises have become less well-equipped. In particular, the number of tractors decreased by 22.4% (Table 5). The fleet of combine harvesters, corn harvesters, and forage harvesters was also reduced by 13.5%. In addition, there was a significant decrease in the number of ploughs (-12.0%), seed drills (-16.4%), and cultivators (-4.6%) in agricultural enterprises.

Table 5. Impact of a full-scale war on the agricultural machinery fleet in Ukraine: the dynamics of the availability of various types of equipment in enterprises in 2016-2024 and losses, thousand units. *(Source: 2016-2019 Agriculture of Ukraine, n.d., 2020-2024 – own calculations and data from Kyiv School of Economics, 2025)*

Type of equipment/years	2016	2017	2018	2019	2021	2024	2024 to 2021 ±, %
Tractors, total	132.7	129.3	128.7	130.5	132.4	102.7	-22.4
Ploughs	49.3	49.1	49.9	51.4	52.5	46.2	-12.0
Cultivators	71.7	70.1	70.5	71.6	72.2	68.9	-4.6
Harrows	192.0	181.4	161.1	160.0	163.1	152.6	-6.4
Seeders	67.2	66.3	65.1	66.5	67.5	56.4	-16.4
Combine harvesters, corn harvesters, and forage harvesters	33.8	32.9	31.5	31.6	31.8	27.5	-13.5

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Over the past 10-15 years, domestic production of agricultural machinery has experienced a catastrophic decline. The largest reduction occurred in the production of tractors (18 times) and tractor mowers (17 times). Production of ploughs, cultivators, and seeders also decreased significantly, by 11.1, 7.8, and 5.7 times, respectively (Statistical Yearbook of Ukraine, n.d.).

A significant reduction in the share of sales of domestic agricultural machinery – from 52.3% in 2012 to 20.5% in 2023 – is a symptom of a deep crisis in the industry. This was conditioned by quality problems, technological lag, and, as a result, a decrease in demand for Ukrainian equipment (calculated based on the data from the State Customs Service of Ukraine, n.d., and Statistical Yearbook of Ukraine, n.d.).

In 2024, there was a decrease in imports of machinery for the agro-industrial complex of Ukraine by 30% compared to 2021. However, the total volume of imports amounted to USD 988.7 million, which indicates a significant need for foreign equipment. The largest import items included tractors (USD 404.2 million), combine harvesters (USD 159.2 million), and sowing equipment (USD 122.7 million) (Official website of the State Customs Service of Ukraine, n.d.).

Navrotskyi, Petrov & Kovalev (2024). noted that an important strategic factor that affects the material and technical support of agricultural enterprises and the development of agricultural engineering is the programme of partial compensation of expenses for the purchase of domestic agricultural machinery and equipment (Table 6) (Compensation programme for domestic agricultural machinery, 2024). After a two-year break in 2022-2023, this programme was resumed, and the budget provided funding in the amount of UAH 1 billion. In 2024, agricultural producers spent more than UAH 4.2 billion on machinery and equipment. According to the programme, 297 tractors and almost 3 thousand units of sowing and tillage equipment (Table 6) were purchased in 2024.

Table 6. Quantity of agricultural machinery purchased under the partial compensation programme (units). *(Source: compensation programme for domestic agricultural machinery, 2024).*

Equipment type	Year						
	2017	2018	2019	2020	2021	2017-2021	2024
Tractors	88	305	214	156	170	933	297
Combine harvesters	0	9	10	1	5	25	–
Grain carriers	1	37	4	0	0	42	5
Sowing and tillage equipment	870	3,552	4,123	6,009	5,394	19,948	2,971
Other machinery and equipment	1,947	13,279	20,724	8,780	25,639	70,369	5,638
Total	2,906	17,182	25,075	14,946	31,208	91,317	8,911

The organisation of its own production of mini-agricultural machinery, including tractors and tillers, focused on the cultivation of small areas in private and small farms, can become a promising way to develop Ukrainian mechanical engineering. This will not only meet the needs of the domestic market, but also effectively compete with the import of cheap equipment from China.

Direct agricultural losses from the war, recorded at the beginning of 2025, amounted to USD 11.2 billion (Table 7). More than half of these losses (58%, or USD 6.5 billion) fell on the destruction or damage of agricultural machinery. A significant share was also accounted for by losses of granaries and theft/loss of factors of production and finished products – 17% each (USD 1.9 billion) for each category. The remaining 8% (USD 0.9 billion) fell on other direct losses.

Table 7. Volumes of direct losses (destroyed, destroyed and damaged) caused to agriculture in Ukraine as a result of the war with the Russian Federation as of January 1, 2025. *(Source: Report on direct damage to infrastructure from destruction as a result of Russia's military aggression against Ukraine as of November 2024, 2025)*

Types of losses	Unit of measurement	Initial number of objects	Number of damaged objects	Remaining number of objects	Damaged, %	Loss estimate, USD billion
Agricultural machinery	units	958,987	178,440	780,547	18.6	6.5
Granaries	capacity, thousand tonnes	11,351	3,341	8,010	29.4	1.9
Stolen/lost factors of production and finished products	X	X	X	X	X	1.9
Other direct losses	X	X	X	X	X	0.9
Total direct losses	X	X	X	X	X	11.2

Most of all, agricultural machinery was lost during the fighting, in particular: about 30 thousand tractors, 2.5 thousand combine harvesters, 11 thousand seeders, and 8.7 thousand ploughs.

It was established that the main strategic areas for overcoming the negative consequences of the war on investment and material and technical support of the agricultural sector are: creation of a favourable investment environment for attracting financial contributions to the development and restoration of production of machinery, organisation of joint ventures engaged in the production of innovative, productive and environmental equipment; implementation of a state protectionist policy that provides for limiting the import of low-quality equipment at low prices by setting quotas and increasing customs rates; restoration of state programmes that finance the restoration and development of agricultural machinery in Ukraine; support from the state to increase the production of mini-equipment; creation of a regime of maximum assistance for strategic imports of equipment by reducing the tax burden; evacuation of agricultural engineering enterprises and their employees from war zones, and organisation of training of new specialists.

DISCUSSION

The results obtained in this study allow for a comprehensive scientific interpretation of the investment and technological processes taking place in Ukraine's agricultural sector during the pre-war, wartime, and post-war periods. The identified increase in capital productivity by 42.9% and the decrease in capital intensity by 30% in 2021-2023 indicate improved efficiency in the use of fixed capital; however, the nature of this improvement differs significantly from the trends described in existing scholarly literature. Unlike the commonly accepted interpretation, where efficiency gains are attributed exclusively to modernization, our analysis shows that these changes are also the result of reductions in land area, workforce numbers, and the loss of technical assets. This means that productivity indicators are rising due to the forced concentration of resources rather than solely through technological renewal.

In the works of Marie Vander Donck et al. (2021), the focus is on global trends in fixed capital formation and its impact on productivity. However, such studies do not account for the context of large-scale shocks caused by military actions, which alter the structure of capital provision and limit opportunities for its reproduction. In contrast, our study is the first to demonstrate that changes in capital efficiency under wartime conditions have a specific character that cannot be accurately assessed without considering machinery losses, infrastructure destruction, and the redistribution of land resources.

Similar discrepancies appear when comparing our results with the research of Yared Deribe Tefera, Bisrat Awoke, and Thomas Daum (2025), where mechanization is viewed primarily as a factor of socio-economic development and improved well-being. The Ukrainian case differs significantly: mechanization during wartime becomes a tool for compensating losses rather than solely for modernization. Our analysis shows that investments in machinery during the war have a dual nature: they simultaneously restore the basic technical potential and create prerequisites for future innovations. This conclusion adjusts classical approaches to understanding mechanization and expands the boundaries of its interpretation in modern economic science.

The conclusions of Tamrat Gebiso and colleagues (2023) regarding the importance of access to mechanization services and market infrastructure are valuable, but they do not consider situations where disruptions in logistics and labor shortages create fundamentally new barriers to the effective use of machinery. Our study introduces a security dimension to investment decisions for the first time, allowing technical re-equipment to be assessed not only in economic but also in risk-related categories – an aspect absent in previous scientific models.

The works of Zhang, Cai, and Wang (2025) confirm the key role of government investment in ensuring the productivity of agricultural production. However, the full-scale war severely limits Ukraine’s policy instruments, making traditional support measures largely ineffective. Our study substantiates that, under wartime conditions, the policy emphasis should shift from compensatory programs to protectionist measures, localization of machinery production, and the development of machine-building clusters. This approach significantly expands previous research and adapts it to the Ukrainian institutional context.

Comparison with studies by Malec and other authors (2024) reveals another methodological distinction. In their works, technological innovation is the main determinant of long-term growth. Our results do not contradict this, but they highlight the importance of basic restoration of technical infrastructure, without which innovations cannot be implemented. Thus, modernization in Ukraine requires a two-stage model: first, reconstruction, then technological upgrading. This conclusion represents significant scientific novelty and complements existing theoretical frameworks on agricultural sector modernization.

Overall, the comprehensive set of conducted analyses has enabled the development of a new approach to assessing investment provision in Ukraine’s agricultural sector. Unlike previously published works, our study integrates the evaluation

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of actual losses of fixed assets, an analysis of changes in capital productivity accounting for structural distortions, and the formation of the concept of dual investment needs, in which the restoration and modernization of the technical base are interconnected processes. This makes it possible to propose a well-grounded model of state support that accounts for the specificities of post-war reconstruction and ensures sustainable capital reproduction in the agricultural sector.

CONCLUSIONS

The war in Ukraine has led to a significant deterioration in the situation in the agricultural sector, particularly in the field of investment and logistics. This was manifested in a decrease in investment attractiveness due to high risks, destruction of agricultural machinery production capacities, difficulties with the import of equipment, and significant losses of equipment and logistics infrastructure as a result of hostilities.

The increase in gross value added in agriculture by 30.7% in the pre-war period was made possible by a reduction in the number of employees and a simultaneous increase in the volume of fixed assets. An important consequence of these changes was a 30.7% reduction in the capital intensity of production, which made the industry more adaptive to the challenges of wartime. The increase in capital availability (by 11.5%) and capital availability (by 8.1%) of agricultural enterprises also contributed to improving the efficiency and sustainability of the industry.

In 2022-2024, there was an unstable dynamics of capital investment in the agricultural sector of Ukraine. The war led to a drop in investment by a third, from USD 2.5 billion (2021) to USD 1.7 billion (2023). Financing was almost entirely carried out at the expense of enterprises' own funds (more than 95%), with a minimal share of bank loans and no state financing.

Fixed assets of production and capital investment in Ukraine significantly differed from the indicators in the EU and Great Britain, lagging ten times behind. For example, in Ukraine, fixed assets worth USD 17.9 billion were used in agriculture, while in the leading European countries this figure was ten times higher: in Germany – USD 200.7 billion, in Italy – USD 169.2 billion, and in the UK – USD 138.0 billion.

Despite the decline in the volume of equipment imports due to the war, the Ukrainian agro-industrial sector continues to need modern equipment. This opens up significant opportunities for domestic machine builders to focus on increasing agricultural machinery production, including through partnerships with the world's leading brands, to meet market needs during the war and post-war periods.

The success of joint projects in the production of agricultural machinery directly depends on a large domestic sales market. Since the state cannot yet guarantee it, the Ukrainian mechanical engineering industry will continue to lose ground. This will lead to the fact that Ukrainian farmers will be forced to buy modern imported equipment. Accordingly, the main part of large-sized, innovative, and high-tech agricultural machinery, including combine harvesters, tractors, and seed drills with precision farming technologies, will be either imported or produced in Ukraine, but with the participation of foreign partners.

In the near future, it is strategically important to provide agricultural enterprises with a sufficient number of fixed assets of production, especially machinery and equipment. This requires improving the mechanisms for updating and expanding them, attracting significant investment, and developing economic models that encourage the effective use of these funds and link their financing with production performance.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

All authors have contributed equally.

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CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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НАУКОВІ ЗАСАДИ РОЗВИТКУ ІНВЕСТИЦІЙ ТА ОНОВЛЕННЯ КАПІТАЛУ АГРАРНОГО СЕКТОРА УКРАЇНИ

Інвестиції та сучасне матеріально-технічне оснащення є ключовими чинниками сталого розвитку аграрного сектора, які сприяють зростанню виробництва, підвищенню продуктивності праці та зміцненню продовольчої безпеки. Модернізація сільського господарства шляхом оновлення основних засобів забезпечує ефективніше використання ресурсів, підвищення віддачі від капіталу та скорочення виробничих витрат. Український аграрний сектор під час війни зазнав значних втрат: скорочення інвестицій, руйнування виробничої інфраструктури, ускладнення логістики постачання техніки та зниження доступу до фінансових ресурсів.

Метою дослідження є аналіз сучасного стану матеріально-технічного забезпечення сільськогосподарського виробництва, виявлення основних тенденцій його розвитку та розробка пропозицій щодо відновлення інвестиційної активності й технічного потенціалу галузі.

У дослідженні використано монографічний, порівняльний, аналітичний, табличний, графічний та абстрактно-логічний методи. Установлено, що процеси реформування аграрних підприємств спричинили кризові явища у формуванні їхньої технічної бази, що негативно позначилося на забезпеченості виробництва основними засобами. Дослідження виявило міцний зв'язок між інвестиційною активністю, технічним оснащенням і рівнем ефективності використання капіталу.

Дослідження виявило тенденцію до зниження ефективності використання основних засобів і капітальних інвестицій у довгостроковому періоді. Водночас скорочення кількості техніки не є ознакою занепаду, а свідчить про підвищення продуктивності наявних машин і проблеми у вітчизняному машинобудуванні, яке не задовольняє потреб аграрного сектора.

Запропоновано напрями вдосконалення технічного забезпечення сільського господарства, що передбачають інноваційний розвиток, оновлення техніко-технологічної бази, активізацію інвестиційної діяльності й посилення державної підтримки для забезпечення сталого розвитку аграрного виробництва.

Ключові слова: основні виробничі засоби, капіталооснащеність, сільськогосподарська техніка, ефективність, валова додана вартість, капітальні інвестиції, державна підтримка

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