

PRIORITY AREAS OF INTEGRATION OF INNOVATION INTO THE STRATEGY FOR ENSURING SUSTAINABLE DEVELOPMENT OF THE AGRICULTURAL INDUSTRY

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Abstract. The *purpose* of the article is to identify key areas for integrating innovations into the strategic processes of ensuring the agricultural sector's sustainable development, with the aim of improving its efficiency, competitiveness and ability to adapt to economic, environmental and social challenges. *Methodology.* The study of priority areas for incorporating innovations into the strategic framework to ensure the sustainable development of the agricultural sector is based on the thorough application of theoretical, analytical and empirical methods. These methods enable an in-depth evaluation of the effectiveness of innovative solutions and their impact on the economic, environmental and social sustainability of the agricultural sector. The research methods include: theoretical analysis (to examine scholarly sources, as well as international and national experience in the implementation of innovations in agriculture, and to identify conceptual approaches to sustainable development and ESG-oriented financing); the systematic approach (with a view to conducting a comprehensive assessment of the agricultural sector as an integrated system encompassing production, financial, environmental and social components, taking into account global and local challenges; analytical methods – in particular SWOT analysis, PESTEL analysis and financial and economic assessments – to identify key issues and potential avenues for integrating innovation); empirical methods (for the collection and processing of statistical data, expert surveys of managers of agricultural enterprises and institutional representatives, and the evaluation of the effectiveness of existing innovative practices); forecasting and modelling methods (to develop scenarios for the implementation of innovative solutions and to assess the expected economic, environmental and social outcomes of their integration). The amalgamation of these methodologies guarantees a scientifically substantiated and praxis-oriented evaluation of pivotal avenues for innovation integration, thereby facilitating the formulation of recommendations for the development of sustainable development strategies for the agricultural sector and the provision of support for Ukraine's post-war economic recovery. The *findings* of the study suggest that integrating innovations into the strategy to ensure the sustainable development of Ukraine's agricultural sector has significant potential, particularly in wartime and during post-war recovery, but this potential is not being realised to its fullest extent. It has been established that the efficiency of agricultural production can be substantially increased through the implementation of technological, digital and environmentally oriented innovations; the development of co-operative and cluster-based forms of interaction; and the strengthening of integration between science, education and agribusiness. The key drivers of sustainable development are adaptation to climate change, the adoption of resource-efficient and low-carbon technologies, the development of organic production methods and the digitalisation of management processes. At the same time, a number of systemic constraints have been identified, including insufficient innovation financing, fragmented institutional support, low levels of innovation among agricultural enterprises and regional disparities in access to modern technologies. The prospects for enhancing the effectiveness of innovation integration are found to be associated with the development of public–private partnerships, improvements to financing mechanisms, modernisation

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of the material and technical base, development of innovation and digital infrastructure, and strengthening the competitiveness of agricultural products in domestic and international markets. *Practical implications.* The results obtained can be used to inform managerial decisions regarding the integration of innovations into sustainable development strategies for the agricultural sector at national, regional, and enterprise levels. Diagnosing the financial, institutional and technological determinants of innovative development enables priority areas for state support to be identified, financing mechanisms to be optimised, and private and international investment to be stimulated, particularly in the context of post-war recovery. The recommendations for implementing digital, resource-efficient and environmentally oriented innovations are of practical significance. These innovations contribute to increased productivity, financial resilience and the adaptability of agricultural enterprises to risks. Implementing the proposed approaches creates the conditions necessary to enhance the competitiveness of agricultural products, ensure adherence to ESG principles, improve resource management and establish an innovation-oriented model for the sustainable development of Ukraine's agricultural sector. *Value/Originality.* The study provides a systematic overview of the key areas for incorporating innovations into a strategy that ensures the sustainable development of the agricultural sector, taking into account global challenges and post-war recovery. This is of significant importance for developing effective national, regional and corporate agricultural policies. The research's scientific novelty lies in integrating the concepts of sustainable development, digital transformation, and ESG-oriented financing into a unified analytical model for the strategic development of the agricultural sector. The focus is on technological, digital and environmental innovations; the development of the institutional environment and human capital; and collaboration between science, education and business. These factors create the conditions necessary to enhance production efficiency, adaptability to risk, environmental security and the long-term competitiveness of Ukraine's agricultural sector.

Keywords: innovations, agricultural sector, sustainable development, strategy, digital technologies, green investments, precision agriculture, institutional environment, financial support.

JEL Classification: Q10, Q16, O33, Q56, G32, L26

1. Introduction

The contemporary agricultural sector in Ukraine is undergoing intensive transformation, driven by globalisation, technological modernisation and economic challenges, including the consequences of military action. Following significant infrastructure damage and losses, the agribusiness sector must not only restore its production capacity, but also ensure its resilience, competitiveness and integration into European and global markets. In these circumstances, innovation becomes a vital factor in optimising resources, reducing environmental pressure and implementing digital and "green" technologies in accordance with ESG principles and global sustainable development standards.

An analysis of international experience shows that effectively integrating innovations into the strategic frameworks of agricultural enterprises improves their financial sustainability, encourages co-operation and cluster-based production, and promotes the adoption of environmentally friendly technologies. However, Ukrainian agricultural enterprises face several challenges, including limited access to financial resources, inadequate adaptation to digital solutions, insufficient institutional support, and a shortage of skilled personnel.

This situation creates an urgent need to prioritise the integration of innovations into the agricultural

sector's sustainable development strategy, enabling the simultaneous achievement of economic, social and environmental goals. The aim of scholarly research into these areas is to identify effective innovation implementation mechanisms, assess their impact on production modernisation and competitiveness, and ensure the long-term resilience of Ukraine's agricultural sector in the context of post-war recovery.

The article aims to identify key areas for integrating innovations into the strategic processes of ensuring the agricultural sector's sustainable development, with the goal of improving its efficiency, competitiveness, and ability to adapt to economic, environmental, and social challenges.

To achieve this objective, the article addresses the following research tasks: an analysis of theoretical approaches to the sustainable development of the agricultural sector and the role of innovation in ensuring economic, social and environmental sustainability; assessment of the current state of innovation activity in Ukraine's agricultural sector and identification of the main problems and obstacles to the implementation of innovations; study of international experience in integrating innovations into strategies for the sustainable development of the agricultural sector and assessment of the possibilities for adapting this to Ukrainian conditions, taking into account post-war recovery; identifying priority areas for the implementation of

digital, environmental and ESG-focused innovations in the strategies of agricultural enterprises; developing methodological approaches to assessing the effectiveness of innovation integration and forecasting their impact on the development of the agricultural sector; and formulating practical recommendations for government bodies, agricultural enterprises and investors aimed at stimulating innovation and ensuring the sector's sustainable development.

The study of priority areas for integrating innovations into the strategic framework for the sustainable development of the agricultural sector is based on the comprehensive application of theoretical, analytical and empirical methods. This allows for a holistic assessment of the effectiveness of innovative solutions, as well as identifying their impact on the economic, environmental and social sustainability of the agricultural sector. The research methods include: theoretical analysis, which is used to examine academic sources, as well as international and national experience of implementing innovations in the agricultural sector, and to identify conceptual approaches to sustainable development and ESG-focused financing; a systems approach, applied to comprehensively assess the agricultural sector as an integrated system encompassing production, financial, environmental and social components, taking into account global and local challenges; analytical methods, including SWOT analysis, PESTEL analysis and financial-economic assessments, used to identify key issues and potential avenues for integrating innovations; empirical methods used to collect and process statistical data and expert surveys of agricultural enterprise managers and institutional representatives, as well as to assess the effectiveness of existing innovative practices; and forecasting and modelling methods, which are used to develop scenarios for the implementation of innovative solutions and to assess the expected economic, environmental and social outcomes of their integration.

This combination of research methods provides a scientifically sound and practical assessment of the most important areas for integrating innovation. This enables recommendations to be made for developing sustainable agricultural sector strategies and supporting Ukraine's economic recovery after the war.

This study focuses on integrating innovations into the sustainable development strategies of the agricultural sector. It particularly analyses the priority areas of digitalisation, "green" technologies, and ESG-oriented financial solutions. These solutions aim to enhance the efficiency, competitiveness, and resilience of agricultural enterprises in the context of Ukraine's post-war recovery. The research results enable one to identify the specific mechanisms and instruments for implementing innovation, forecast their impact on the economic, environmental and social aspects of the agricultural sector, and provide public authorities, businesses and investors with recommendations on optimising the sector's strategic development and ensuring the long-term sustainability of agricultural production.

2. Theoretical Foundations of Sustainable Development of the Agricultural Sector and the Role of Innovation

The sustainable development of the agricultural sector involves the structured advancement of agriculture and related industries, with the aim of ensuring economic efficiency, social equity and environmental security. This involves the rational use of resources and the implementation of innovations and technologies, as well as the sector's ability to adapt to global challenges and post-war recovery conditions.

To systematise the theoretical foundations of the sustainable development of the agricultural sector and identify its core reference points, the key principles forming the basis of balanced economic, social and environmental development are considered, as presented in Table 1.

Table 1
Principles of sustainable development of the agricultural sector

Principle	The essence of the principle	Practical importance for the agricultural sector
Economic efficiency	Ensuring the profitability and competitiveness of enterprises.	Optimisation of production processes is key to increasing productivity and attracting investments.
Social responsibility	Supporting employment and the well-being of the population.	Job creation, development of rural communities, improving living standards.
Environmental safety	Preserving natural resources and minimising negative impacts.	Rational use of land, water, reducing emissions and soil degradation.
Innovation	Introducing the latest technologies and practices.	Digitalisation, precision agriculture, "green" technologies and ESG approaches.
Risk orientation	Adapting to economic, climatic and geopolitical challenges.	Creation of insurance systems, diversification of production, increasing financial sustainability.
Long-term perspective	Ensuring sustainable development for future generations.	Investment planning, development of resource-efficient technologies, support for environmental initiatives.

Source: (Kaletnik, Sakhno, Pryshliak, Lutkovska, Kolomiets, 2025; Ridei, Bakhmat, Plahtiy, Polova, Holovnia, 2021)

In contemporary conditions, the sustainable development of the agricultural sector is increasingly shaped by the ESG framework, which involves integrating environmental, social, and governance aspects into the strategic management system. Implementing these components requires the adoption of innovative solutions, particularly digital and environmentally focused ones, to ensure a balance between economic efficiency, social responsibility, and environmental security (Tomashuk, Germaniuk, Koval, 2025). Figure 1 illustrates the interrelationship between the key components of the sustainable development of the agricultural sector, taking into account ESG orientation and the role of an innovation-driven approach.

Innovation in the agricultural sector is a key factor in enhancing enterprise efficiency and competitiveness, as it facilitates the modernisation of production processes, optimises resource use and encourages the adoption of advanced technologies. Implementing digital solutions, precision agriculture, automation and environmentally friendly technologies reduces costs, increases productivity and product quality, and ensures compliance with international standards and ESG requirements. Moreover, innovations support

agricultural enterprises in adapting to market and climate-related challenges. They create conditions that attract investment and foster the development of cooperative organisational structures. This significantly strengthens the enterprises' resilience and competitive advantage at national and international levels.

In order to formulate well-founded public and managerial decisions regarding the innovative modernisation of the agricultural sector, it is advisable to draw on international experience in integrating innovations into agriculture. This experience demonstrates effective instruments of regulatory support, financial incentives, and the implementation of ESG approaches, which are systematised in Table 2.

Experience from around the world shows that successfully integrating innovations into the agricultural sector requires a combination of active public policy, a well-developed institutional environment, and private capital investment. Leading countries prioritise the adoption of digital, biotechnological and resource-efficient solutions within the framework of ESG, ensuring simultaneous growth in productivity, environmental sustainability and social responsibility within the agricultural industry. Financial incentives

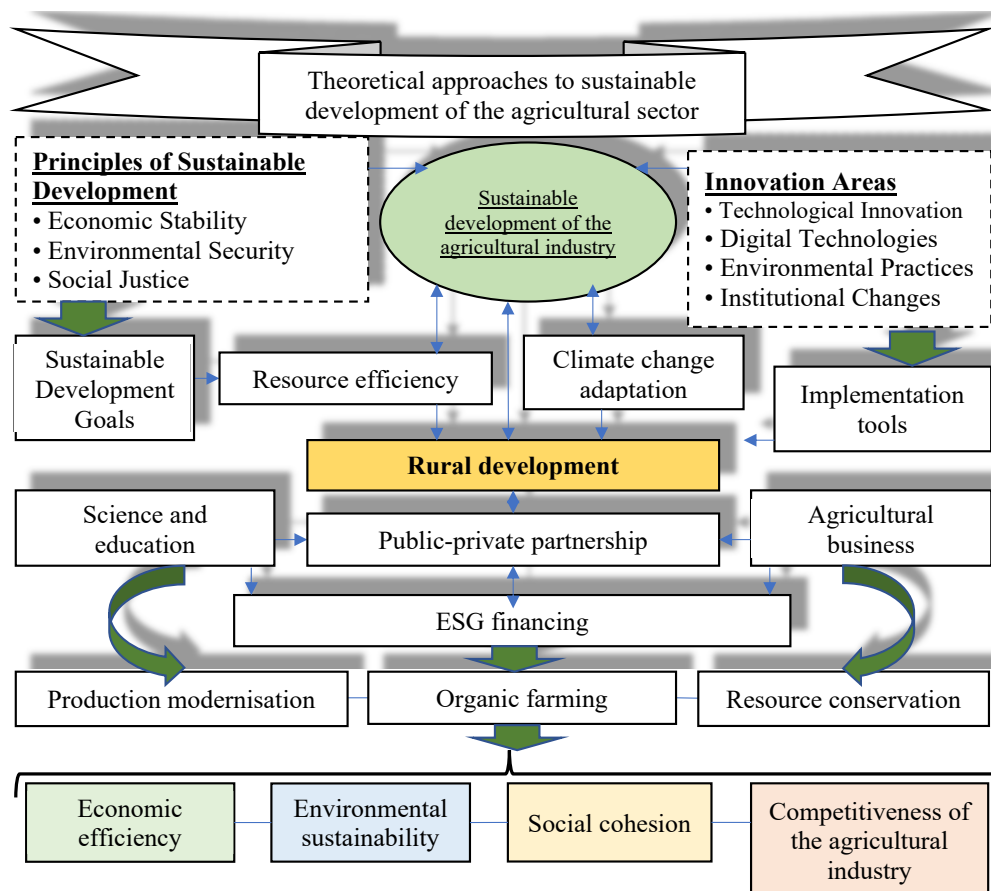


Figure 1. Components of sustainable development of the agricultural sector taking into account an innovative approach

Source: authors' development

Table 2

International experience in integrating innovations into the agricultural sector

Country	Main innovative approaches	Results and effects
Netherlands	Precision farming, automation, digital platforms.	High productivity, efficient use of resources, leadership in agricultural exports.
USA	Biotechnology, smart franchising, agroinsurance.	Increasing yields, reducing risks, scaling innovative solutions.
Israel	Drip irrigation, soil and water monitoring systems.	Rational use of water resources, resilience to climate challenges.
Denmark	ESG approaches, green technologies, renewable energy.	Reducing environmental impact, developing organic production.
China	Digital platforms, robotics, agrotech startups.	Optimising logistics, increasing productivity and technological level of the agricultural sector.

Source: (Mazur, Fesun, 2021)

for innovation, the development of agricultural innovation clusters, support for science and technology transfer, and the systematic integration of sustainable development principles into agricultural policy all play a key role. This experience is highly relevant to Ukraine and could inform strategies for modernising the agricultural sector, adapted to national conditions and post-war recovery priorities.

3. Analysis of the Current State of Innovation Activity in the Agricultural Sector of Ukraine

The current state of innovation activity in Ukraine's agricultural sector is influenced by European integration processes, digitalisation, climate change and armed conflict. In this context, innovation is a key factor in enhancing the competitiveness of agricultural production, improving the efficiency with which resources are used, and achieving sustainable development goals in line with the ESG framework (Stolyarchuk, 2024). At the same time, the uneven nature of innovation activity among enterprises underscores the necessity of conducting a thorough evaluation of the current prerequisites, obstacles, and opportunities for the advancement of innovation in the agricultural sector (Lupenko, Malik, Shpykulyak et al., 2014).

In order to evaluate Ukraine's innovation potential, it is useful to consider its position in the Global Innovation Index (GII). This index reflects a country's capacity to adopt advanced technologies and utilise innovation resources effectively (see Figure 2).

Ukraine's ranking in the Global Innovation Index (GII) has gradually improved, rising from 45 in 2020 to 66 in 2025. This indicates an overall enhancement of the country's innovation potential. While the innovation input indicator has increased more steadily (from 71 to 80), the innovation output indicator has shown slower progress (from 37 to 54). This discrepancy suggests that there is a mismatch between the available resources and their practical application. While linear trend analysis confirms a positive trajectory, the

lag in outputs emphasises the need to increase the effectiveness of innovation activities and transform resources into tangible products and services.

The digital economy is derived from innovation processes because its formation and development depend on the implementation of new technologies, scientific advances and digital solutions in all areas of economic activity.

According to the Ukraine Recovery Plan (2022), the digital economy's share of Ukraine's GDP increased from 4.3% in 2019 to 5.5% in 2022, with a forecast of 6% by 2025. The linear trend ($y = 0.5543x + 3.7267$) suggests that this figure could rise to 7.7% by 2032, highlighting the steady growth of the digital sector's influence on the economy (see Figure 3).

The Ukrainian Institute for the Future has published expert evaluations and calculations from the "Digital Agenda of Ukraine" initiative, based on World Economic Information Technology Report (DEF) data, regarding the dynamics of the digital economy's share of Ukraine's GDP for 2021–2025, with projections up to 2030. These estimates suggest steady growth, from 3% in 2021 to an anticipated 65% in 2030. Linear regression ($y = 6.6848x - 12.067$) indicates an average annual increase of around 6.7%, reflecting the active digitalisation of the economy and its increasing impact on national GDP (see Figure 4). This trend demonstrates improvements in the efficiency of economic processes and Ukraine's gradual integration into global digital economic transformations.

Innovation activity requires substantial financial resources, encompassing the development of new technologies, the implementation of modern equipment and the support of research projects. Figure 5 shows that, in 2025, the highest research and development (R&D) expenditure as a percentage of GDP is observed in developed economies such as Israel and South Korea, whereas in most other countries, expenditure remains at a medium or low level. This illustrates the correlation between investment in R&D and a nation's technological progress, competitiveness, and innovation potential.

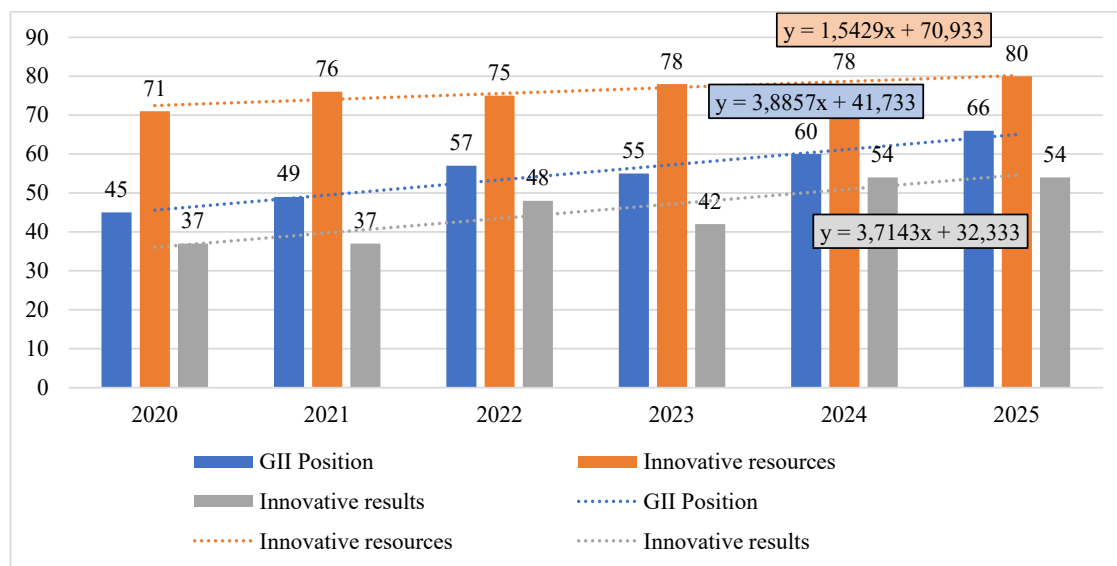


Figure 2. Ukraine's rating on the GII scale (2020-2025)

Source: <https://www.wipo.int/gii-ranking/en/ukraine>

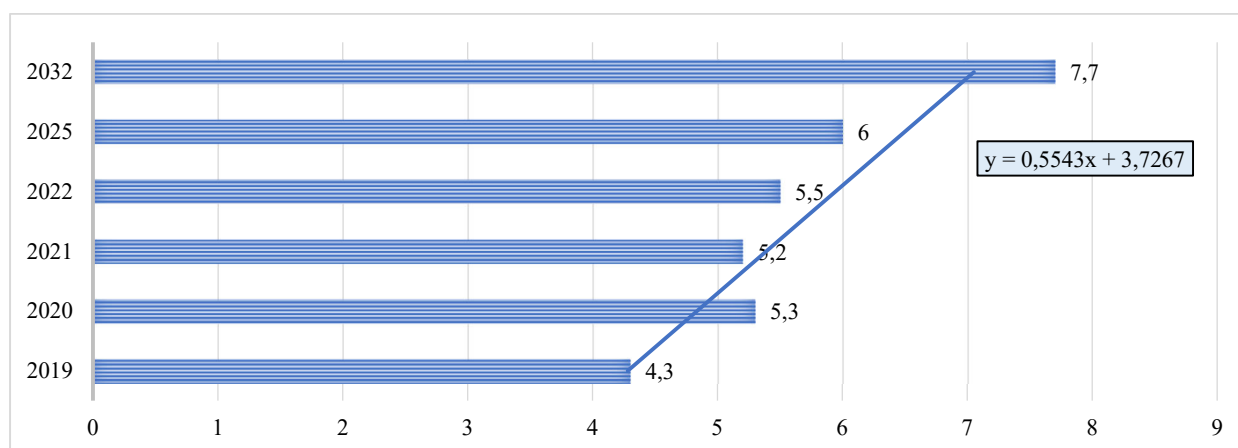


Figure 3. Share of the digital economy in Ukraine's GDP, 2019-2025, forecast until 2032, %

Source: <https://www.kmu.gov.ua/storage/app/sites/1/recoveryrada/ua/economic-recovery-and-development.pdf>

In order to assess the effectiveness of innovation processes, it is necessary to evaluate the level of technological modernisation in the agricultural sector. This can be achieved by using a set of key indicators that reflect the implementation of modern technologies, digitalisation, investment support, environmental responsibility and the development of human capital, as presented in Table 3. These indicators allow enterprises to be evaluated comprehensively in terms of their readiness for innovation, the extent to which they adopt modern technology, and their capacity to enhance efficiency and competitiveness within the framework of sustainable development.

The following system of indicators is proposed for assessing the level of technological modernisation in Ukraine's agricultural sector (Tomashuk, 2025):

An integral index of technological modernisation of the agricultural industry, which provides a generalised assessment of the level of technological modernisation of the agricultural sector, taking into account production, digital, investment and environmental components.

$$I_{TM} = \sum_{i=1}^n w_i \cdot N_i$$

where:

I_{TM} – Integral Index of Technological Modernisation;
 N_i – the normalised value of the i-th modernisation indicator;

w_i – the weighting coefficient reflecting the significance of the indicator ($\sum w_i = 1$);

n – the number of indicators.

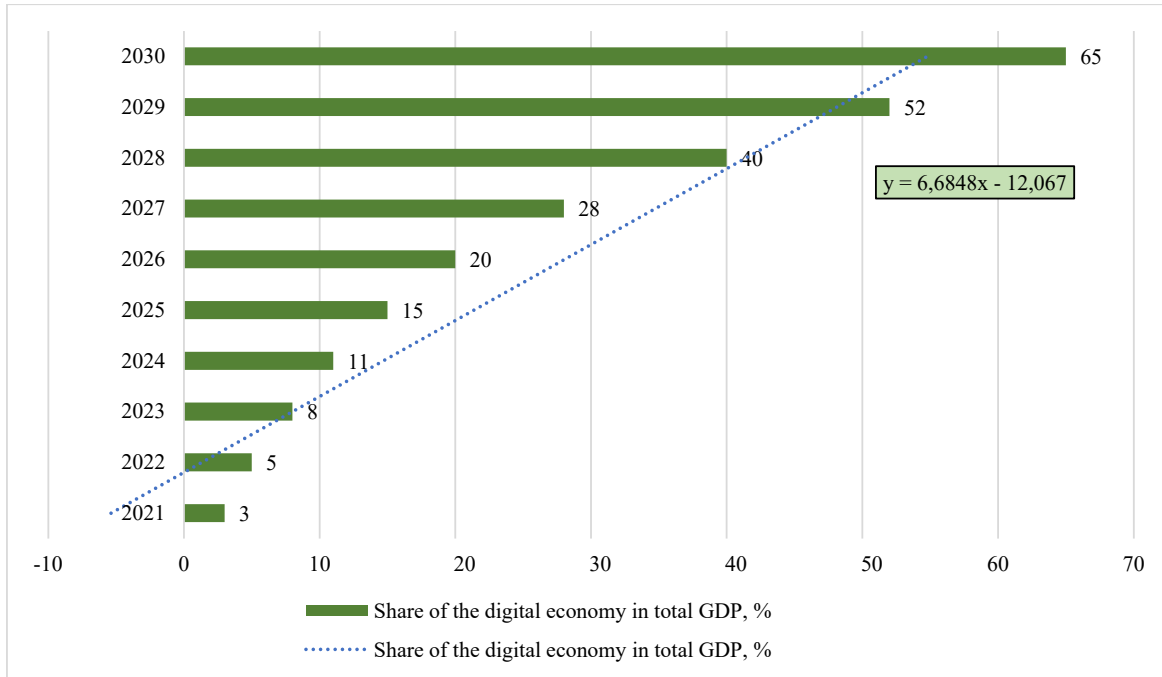


Figure 4. Share of the digital economy in Ukraine's GDP (KPI), 2021-2025, forecast until 2030, %
 Source: https://strategy.uifuture.org/kraina-z-rozvinutoyu-cifrovoyu-ekonomikoyu.html?utm_source.com

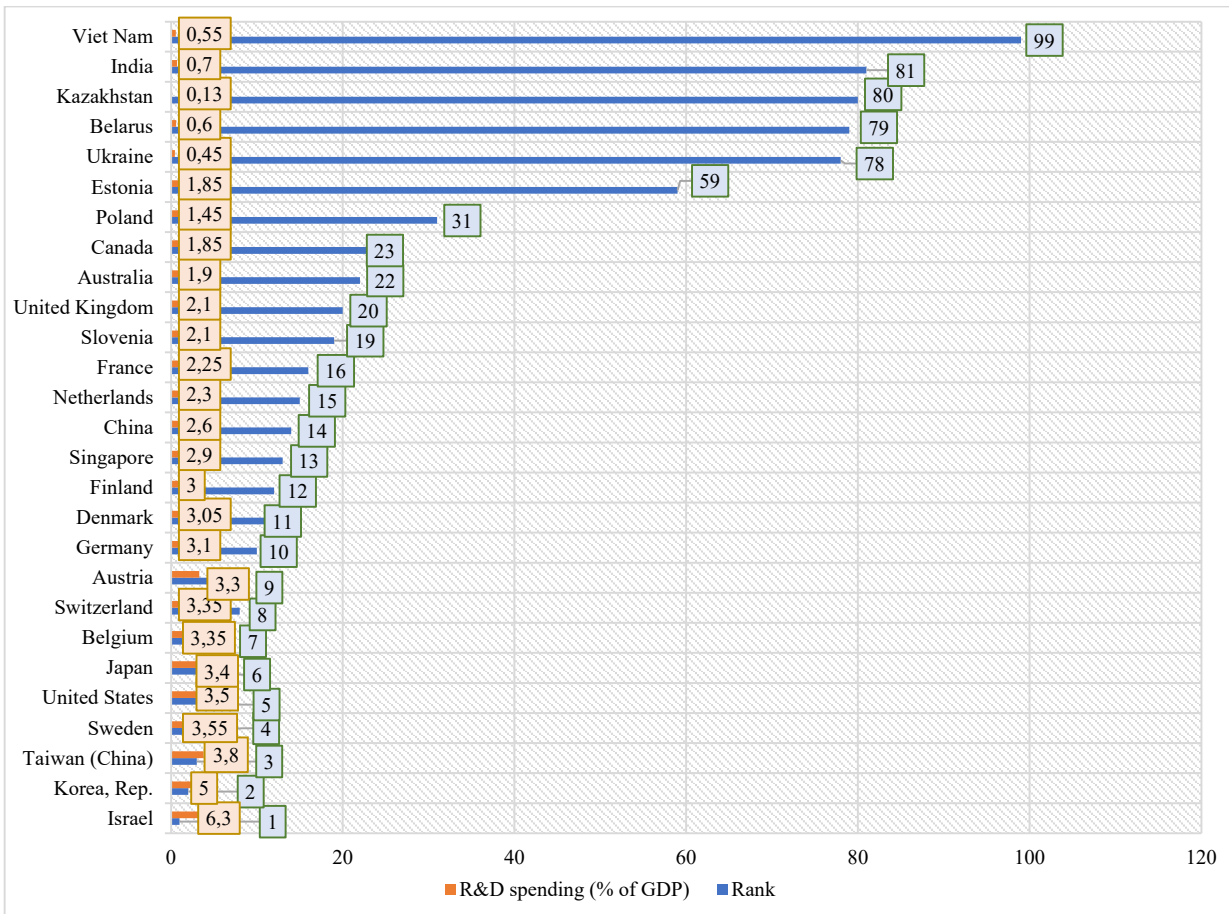


Figure 5. List of countries by R&D spending as a share of GDP (2025 ranking)
 Source: https://statranker.org/digital-innovation/top-100-countries-by-rd-spending-as-a-share-of-gdp-2025/?utm_source.com

Table 3
Indicators of technological modernisation of the agricultural sector

Indicator group	Specific indicators
Production	The share of enterprises with modern technologies implemented (e.g., precision farming and automation), the level of mechanisation, labour productivity and the volume of modernised equipment.
Digitalization	The share of agricultural enterprises using digital platforms and software for production management and the area of land managed through digital systems and the implementation of the Internet of Things (IoT) and sensors.
Investment	The volume of investments in production modernisation, the share of state and private support for technological projects and the number of foreign investments attracted.
Environmental and green technologies	The share of organic production and the use of renewable energy, as well as the volume of measures to reduce greenhouse gas emissions and the chemical load on soils.
Innovation and personnel	The number of new technologies implemented, the proportion of personnel trained to work with them, and participation in research and training programmes.

Source: (Jia, 2021; Lupenko, Malik, Shpykulyak, et al. 2014)

2. The coefficient of technological equipment indicates the extent to which the material and technical base has been updated, and the degree to which outdated technologies have been replaced by modern ones.

$$K_{to} = \frac{V_{mt}}{V_z}$$

where:

V_{mt} – the cost of modernised technological assets;

V_z – the total cost of fixed assets of agricultural enterprises.

3. The coefficient of digitalisation in agricultural production reflects the extent to which digital solutions, precision agriculture and automated management systems are implemented.

$$K_{dig} = \frac{P_{dig}}{P_{zag}}$$

where:

P_{dig} – the area of agricultural land cultivated using digital technologies;

P_{zag} – the total area of agricultural land.

4. The Modernisation Investment Activity Index indicates the level of investment in technological renewal in relation to the size of the production sector.

$$I_{inv} = \frac{I_{tm}}{Q}$$

where:

I_{tm} – the volume of investment in technological modernisation;

Q – the volume of agricultural production.

5. The coefficient of innovation activity indicates how prevalent innovation processes are in the industry.

$$K_{in} = \frac{N_{in}}{N_{zag}}$$

where:

N_{in} – the number of agricultural enterprises implementing innovations;

N_{zag} – the total number of agricultural enterprises.

6. The coefficient of environmentally oriented modernisation indicates the extent to which

environmental and ESG factors are integrated into the modernisation processes of the agricultural sector.

$$K_{eco} = \frac{V_{eco}}{V_{tm}}$$

where:

V_{eco} – the volume of investment in “green” and ecological technologies;

V_{tm} – the total volume of investment in technological modernisation.

7. The generalised assessment model enables a comprehensive evaluation of the level of technological modernisation in Ukraine’s agricultural sector and is used for: comparative analysis of regions; monitoring the progress of post-war recovery; and informing strategic decisions in the field of sustainable development.

$$I_{TM} = w_1 K_{to} + w_2 K_{dig} + w_3 I_{inv} + w_4 K_{in} + w_5 K_{eco}$$

The presented system of indicators enables a thorough evaluation of the degree of technological modernisation in Ukraine’s agricultural sector, considering production, digitalisation, investment, innovation and environmental factors. The integral index and the overall evaluation model facilitate regional comparisons and monitoring of modernisation and post-war recovery dynamics. They also provide a basis for strategic management decisions in the field of sustainable development.

In order to gain a more profound understanding of the strengths and weaknesses, as well as the opportunities and threats associated with the development of innovation activities in Ukraine’s agricultural sector, it is appropriate to apply a SWOT analysis, as presented in Table 4.

This analysis highlights the sector’s scientific expertise and experience in digitalisation. However, it also indicates limited financing and a shortage of skilled personnel. Key opportunities include state and international support, as well as growing demand for environmentally friendly products. Threats, however, are linked to military and economic risks, as well as regulatory barriers.

Table 4

SWOT analysis of the current state of innovation activity in the agricultural sector of Ukraine

Strengths	Weaknesses
<ul style="list-style-type: none"> • Availability of research institutions in the field of agro-industrial complex; • experience in implementing precision agriculture and digital technologies; • potential for organic and “green” production. 	<ul style="list-style-type: none"> • Limited funding for innovation projects; • low level of digital competence of farmers; • shortage of qualified personnel; • limited integration with international innovation platforms.
Opportunities	Threats
<ul style="list-style-type: none"> • State innovation support programmes; • international funding and grants; • development of co-operation and clusters; • growing demand for ecological and certified products. 	<ul style="list-style-type: none"> • Military and economic risks; • Market instability and price fluctuations; • Slow adaptation to ESG standards; • Bureaucratic barriers and complex regulatory requirements.

Source: (Tomashuk, 2025; Kovbasa, Maznyi, 2024)

To gain a comprehensive understanding of the external factors influencing innovation in Ukraine's agricultural sector, the PEST analysis presented in Table 5 is a valuable resource. This shows that political, economic, social and technological factors have a significant influence on innovation activities in the agricultural sector. These factors shape financing, workforce readiness, access to technologies and the capacity to adapt to market and ESG trends.

Global challenges such as fluctuations in world agricultural commodity prices, climate change, energy instability and geopolitical tensions significantly impact the pace and direction of innovation in Ukraine's agricultural sector. In the context of post-war recovery, these factors are of particular importance, as enterprises must adapt to limited resources, damaged infrastructure and increased production risks (Khaietska, Holovnia, Pavlyuk, Osipova, 2023). At the same time, these challenges provide an incentive to actively implement innovations, such as digitalisation, precision farming, "green" technologies and ESG initiatives. These

innovations enhance the agricultural sector's efficiency, resilience and competitiveness, thereby supporting its rapid recovery and modernisation.

4. Priority Areas for Introduction of Innovations into the Sustainable Development Strategy for the Agricultural Sector

The overarching objective of incorporating innovations into the sustainable development strategy of the agricultural sector is to achieve a simultaneous enhancement of economic efficiency, ecological balance, and social resilience in agricultural production. Key areas for exploration include the technological modernisation of production processes through digital and resource-saving technologies, the development of precision farming, and automated management systems. These contribute to increased productivity and reduced production costs (Kaletnik, Lutkovska, 2020). A key focus is the greening of agricultural

Table 5

PEST analysis of the current state of innovation activity in the agricultural sector of Ukraine

Category	Influencing factors	Characteristics and implications for innovation
Political	State support programmes for the agricultural sector, tax incentives, regulatory requirements, political instability.	Promote or inhibit the financing and implementation of innovations, determine access to government grants and modernisation programmes.
Economic	Investment volume, credit availability, market fluctuations, inflation, war losses.	Affect the financial ability of enterprises to invest in technologies, access to resources and predictability of development.
Social	Skill level of personnel, demographic changes, consumer priorities, demand for ecological products.	Determine the readiness of personnel to implement innovations, develop co-operation and adapt to new market trends.
Technological	Access to digital platforms, precision agriculture, biotechnology, agrodigitalisation.	Determine the possibilities of modernisation of production, increase productivity, resource efficiency and integration of ESG-oriented solutions.

Source: (Sakhno, Polishchuk, Salkova, Kucher, 2019)

activities by implementing ‘green’ innovations, climate-adapted technologies and circular resource-use models in line with ESG principles and European sustainable development standards. The institutional integration of innovations is equally significant. This involves creating an effective innovation environment, developing agricultural clusters, fostering co-operative links between businesses, scientists and the government, and improving the mechanisms that stimulate

innovation financially (Rosário, Madureira, Marques, Silva, 2022). Implementing these strategies together enhances the competitiveness of the agricultural sector, strengthens its ability to adapt to global challenges and establishes the basis for long-term sustainable development during the post-war recovery period. Figure 6 illustrates the key directions and priorities for the agricultural sector’s development within the context of sustainable development, as set out in the authors’

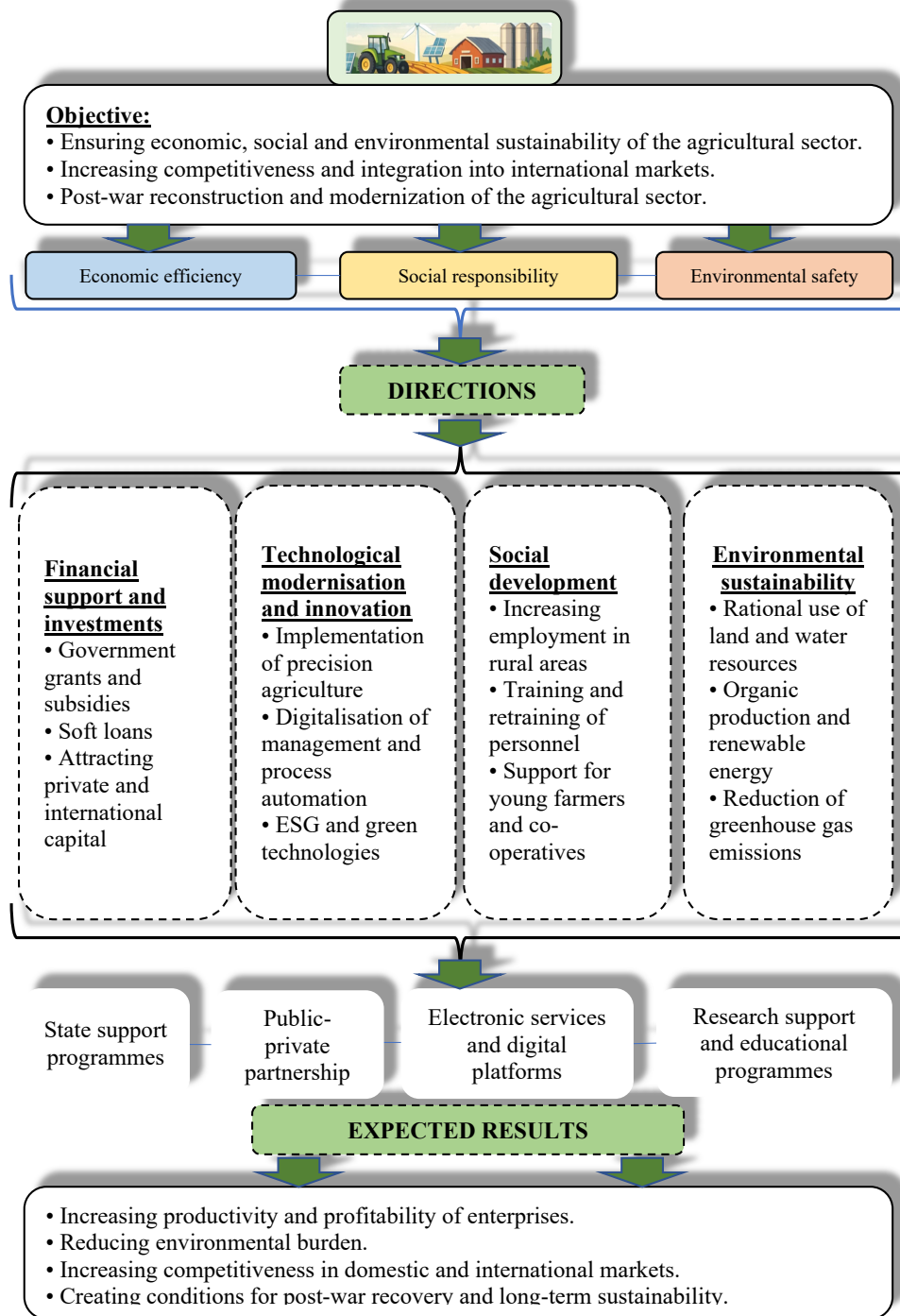


Figure 6. Strategy for sustainable development of the agricultural sector

Source: authors' development

proposed Sustainable Development Strategy for the Agricultural Sector. The strategy integrates economic efficiency, technological modernisation, environmental responsibility, and social development. The strategy incorporates innovations, digitalisation, and "green" technologies to boost the agricultural sector's productivity, competitiveness, and long-term resilience.

Table 6 outlines the primary mechanisms for financing and promoting innovation within the agricultural sector. These include government support programmes, tax incentives, grants, loans and private investments. These mechanisms give businesses access to the resources needed to implement new technologies, boost productivity and integrate innovations into production processes.

The development of institutional environments and co-operation between agricultural enterprises is a key focus for integrating innovation into the sustainable development strategy of the agricultural sector. Effective institutions create conditions for innovation diffusion, reduce transaction costs and enhance the sector's investment attractiveness (Zaremba, Sakhno, Chesnik, Nitsenko, Chikov, Zakharova, Boltovska, 2025; Lohosha, Krychkovskiy, Moroz, Kolesnyk, Vakar, 2024). The development of the institutional environment and co-operation between agricultural enterprises is a key way of integrating innovation into the sustainable development strategy for the agricultural sector. Effective institutions create conditions that encourage innovation, reduce transaction costs and enhance the sector's investment attractiveness (Kirieieva, Pryshliak, Shamanska, Salkova, Kucher, 2019). In the context of Ukraine's post-war recovery, institutional co-operation consolidates resources,

accelerates innovation transfer and facilitates the scaling up of sustainable practices. This enhances the sector's competitiveness and its capacity for long-term balanced development.

5. Assessment of Expected Results and Indicators of the Effectiveness of Innovation Integration

In order to assess the impact of innovation implementation in the agricultural sector, it is important to evaluate the expected outcomes and key performance indicators. This enables progress in modernisation, productivity enhancement and the achievement of sustainable development objectives to be monitored. The socio-economic effects of integrating innovation are reflected in the agricultural sector's increased productivity and competitiveness, the development of human capital, the creation of new jobs, and the adoption of environmentally sustainable practices. This ensures the sector's economic efficiency and socio-environmental resilience (Fig. 7).

In order to assess the outcomes of innovation implementation in the agricultural sector, ecological and technological indicators of integration efficiency (see Table 7) are also utilised, thus enabling an evaluation of their impact on economic performance and sustainable development. It is evident that ecological indicators are indicative of a decline in CO₂ emissions, an enhancement in resource efficiency, an augmentation in ecologically certified land, and a mitigation of soil degradation. Conversely, technological indicators are indicative of the level of production modernisation, the utilisation of digital

Table 6

Effective mechanisms for financing and stimulating innovations in the agricultural sector

Mechanism	Content	Implementation tools	Expected effect
State innovation support	Financing innovative agricultural projects and modernisation	Grants, subsidies, interest rate compensation	Reducing financial barriers to innovation
Preferential lending	Providing access to cheap financial resources	State guarantees, specialized agricultural credit programmes	Increasing investment activity of enterprises
International programmes and donor financing	Attracting resources for restoration and innovative development	EU grants, international financial organisations, recovery funds	Accelerating modernisation and integration into the European market
ESG and "green" financing	Stimulating ecological and socially responsible innovations	Green bonds, climate funds, sustainable banking	Greening of production and compliance with EU standards
Public-private partnership	Joint implementation of innovative projects	Investment agreements, concessions, clusters	Attracting private capital and reducing risks
Tax incentives	Encouraging innovative activity of enterprises	Tax incentives, investment tax credits	Increasing motivation for innovation
Support for agricultural startups	Developing innovative entrepreneurship	Accelerators, venture financing, business incubators	Emerging new technological solutions
Educational and consulting support	Increasing the innovative capacity of agricultural producers	Training programmes, technology transfer	Increasing the efficiency of innovation implementation

Source: (Zaremba, Sakhno, Chesnik, Nitsenko, Chikov, Zakharova, Boltovska, 2025; Sakhno, Polishchuk, Salkova, Kucher, 2019; Pronko, Furman, Kucher, Gontaruk, 2020)

solutions, the intensity of new technology adoption, and productivity growth. Collectively, these indicators furnish a thorough evaluation of the manner in which innovation integration augments productivity and fosters the environmental sustainability of the agricultural sector.

The effective integration of innovations into the strategy for the sustainable development of the agricultural sector has been shown to directly enhance its competitiveness by increasing productivity, optimising costs, and improving the quality and added value of agricultural products (Koval'skiy, 2025).

The strategic integration of digital, technological, and ecological innovations has been demonstrated to enhance resource efficiency, mitigate production and climate-related risks, and streamline adaptation to European market requirements and ESG standards. From a strategic standpoint, this approach fosters long-term financial, environmental, and social resilience within the agricultural sector, thereby strengthening the innovative capacity of enterprises and laying the foundations for accelerated post-war recovery and sustainable economic growth in Ukraine.

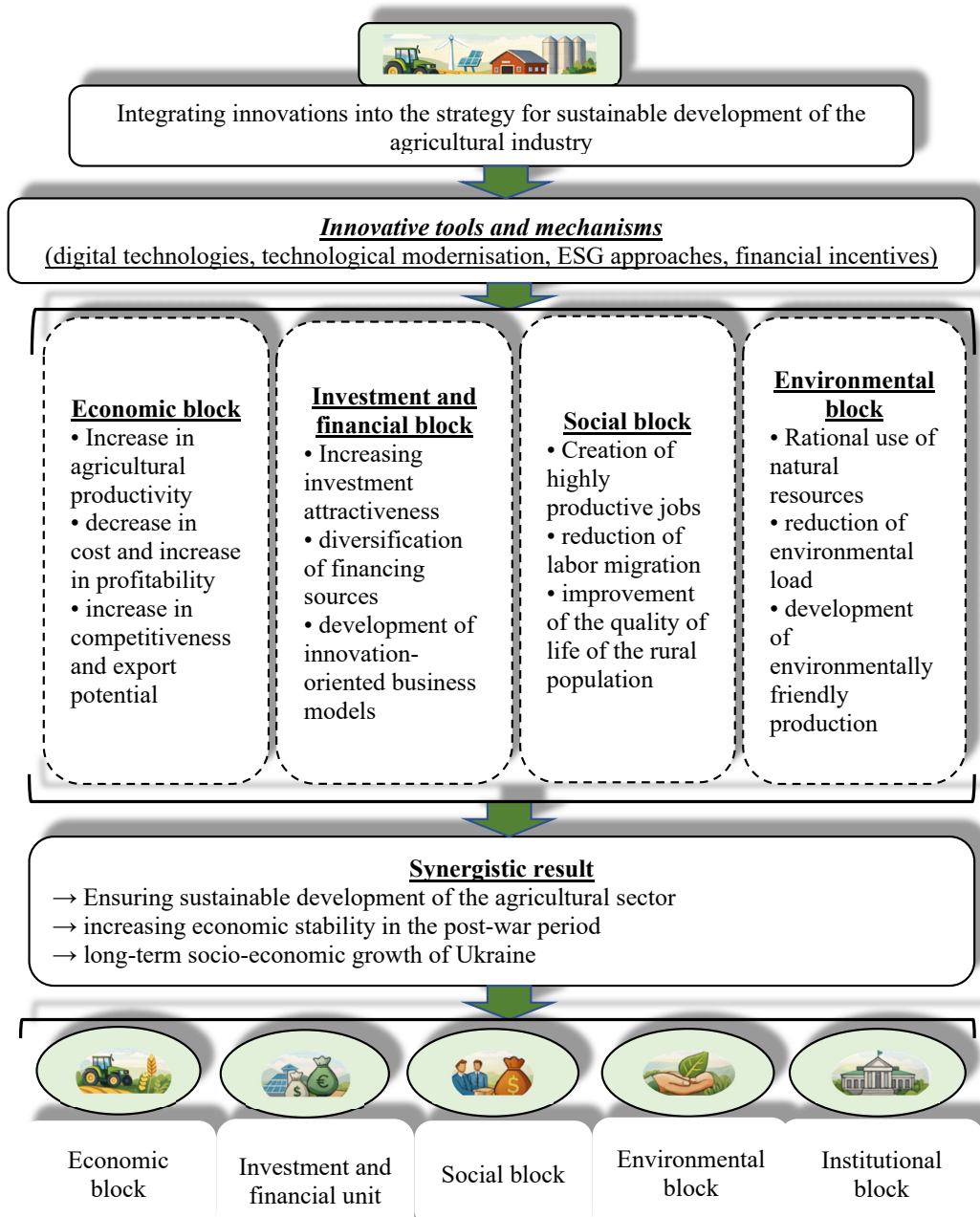


Figure 7. Socio-economic effects of innovation integration

Source: authors' development

Table 7

Environmental and technological indicators of the effectiveness of innovation integration

Indicator group	Indicator	Content and analytical characteristics
Environmental	Reduction of CO ₂ emissions	Reducing the carbon footprint of production through energy-efficient and "green" technologies.
	Level of resource efficiency	Reducing water, fuel, and fertiliser consumption per unit of production.
	Share of ecologically certified areas	Expanding organic and environmentally friendly agriculture.
	Reduction of soil degradation	Restoring fertility through precision agriculture and soil protection technologies.
Technological	Level of technological modernisation	The share of modern technology and digital solutions in production processes.
	Implementation of digital technologies	Using GPS, IoT, Big Data, and agricultural platforms to manage production.
	Innovative activity of enterprises	The number of implemented agricultural innovations and technological solutions.
	Production productivity	Increasing crop yields and product yields through technology.

Source: (Kaletnik, Sakhno, Pryshliak, Lutkovska, Kolomiets, 2025)

6. Conclusions

Innovations have been identified as a system-forming factor in ensuring the sustainable development of the agricultural sector. The level of technological modernisation, resource efficiency, environmental safety, and the long-term competitiveness of agricultural enterprises is determined by innovations. The present state of innovation activity in Ukraine's agricultural sector is characterised by significant development potential, alongside financial, institutional, and infrastructural constraints, which are particularly pronounced in the context of war and post-war recovery. The integration of innovations into the strategy for sustainable development of the agricultural sector must be comprehensive. It should encompass the digitalisation of production processes, the implementation of environmentally oriented technologies, the development of green financing, and adaptation to ESG principles.

Priority areas for innovation-driven development in the agricultural sector include improving innovation

financing mechanisms, developing the institutional environment, promoting co-operation and cluster organisation, and strengthening interaction between science, business and government. Methods of assessing the level of technological modernisation in the agricultural sector are based on a system of quantitative and qualitative indicators, which allow the effectiveness of integrating innovation into the sustainable development strategy to be monitored.

Effectively integrating innovations can have positive socio-economic and environmental effects. These include increased labour productivity, reduced resource intensity in production, improved quality of agricultural products and enhanced export potential for Ukraine's agricultural sector.

Implementing an innovation-based strategy to sustainably develop the agricultural sector is crucial for accelerating post-war recovery, creating sustainable competitive advantages and integrating Ukraine into global agri-food and innovation value chains.

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