Environmental Challenges and Agribusiness Transformation Under Climate Change and Military Conflict

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Abstract

This study examines the environmental challenges facing Ukrainian agribusiness and explores directions for its transformation under climate change and military conflict. The current state of suitability of Ukrainian agricultural lands and the level of chemical load on soils in Ukraine are compared with the corresponding indicators of the countries of Central Asia and Europe. It is revealed how ecological transformations in these regions are related to climate change. The nature and scale of damage suffered by the environment and agriculture of Ukraine as a result of the military conflict have been analyzed here. The purpose of the article is to substantiate the directions and mechanisms of transformation of Ukrainian agribusiness, taking into account climatic, environmental, and military challenges, as well as world experience in adapting agriculture to the consequences of climate change. The study is based on a systematic approach that combines monographic, economic-statistical, and abstract-logical methods, content analysis, and comparative analysis of risks and consequences of climate change for agribusiness in different countries. The findings indicate that Ukrainian agriculture still remains chemically intensive, the area of degraded soils is growing, and water resources are becoming increasingly scarce. These problems are compounded by large-scale environmental and economic losses caused by the military conflict. It follows that the transformation of Ukrainian agribusiness cannot be limited to the climate component alone — it must also take into account military-ecological, resource-economic, European integration, and management challenges. The principal contribution of this study is the systematization of the strategic challenges facing agribusiness transformation and the development of the authors' conceptual model, which integrates organizational and managerial, environmental, financial and investment, and risk management mechanisms. It is based on precision farming tools, circular supply chains, ESG standards and reporting, carbon management, satellite monitoring, digitalization of management, environmental certification, and renewable energy.

Keywords: environmental sustainability, agribusiness, climate change, military-environmental challenges, transformation, land resources, digitalization, sustainable development

1. Introduction

The modern development of the agricultural sector is characterized by a significant increase in the impact of climate change, which transforms the conditions for conducting agricultural production and creates new demands for the functioning and transformation of agribusiness. The increase in the average annual air temperature, changes in the precipitation regime, an increase in the frequency and intensity of droughts, extreme weather events, soil degradation, and a reduction in water resources significantly increase the level of uncertainty and risk in the functioning of agricultural enterprises and require a fundamental reconsideration of approaches to the use of natural resource potential. Under these conditions, traditional

management models, primarily focused on short-term financial performance, are becoming increasingly incapable of ensuring production stability and sustaining the long-term competitiveness of agribusiness.

Climate-related challenges and limited natural resource potential in the EU countries have become the main determinants of changing the strategic course of agricultural development towards increasing its adaptability, resource efficiency, environmental sustainability and risk-oriented management. For Ukraine, the issue of finding directions for environmentally oriented transformation of agribusiness is of particular importance in the context of European integration processes and the damage and destruction caused by the consequences of the military conflict, which increased the risks of qualitative and quantitative changes in natural resources. The combination of climatic and military environmental challenges forms fundamentally new conditions for the functioning of the agricultural sector of Ukraine. This necessitates the revision of the conceptual principles of agribusiness management and the development of resilient models capable of ensuring the effective use of natural resources, increasing the sustainability of agricultural production, and creating the prerequisites for its long-term post-war development.

2. Research Aim and Objectives

The purpose of the article is to substantiate the directions of agribusiness transformation in Ukraine, taking into account the challenges of an environmental and military nature and world experience in minimizing the consequences of climate change in agriculture. To achieve this aim, the following objectives were formulated:

- identify key climatic and environmental risks that affect the natural resource potential of agribusiness and assess their consequences;
- analyze the current state of suitability of agricultural lands of Ukraine and the level of chemical load on soils, taking into account the goals of sustainable agricultural development;
- assess the scale and nature of military-environmental challenges that Ukrainian agribusiness faces today;
- systematize climatic, environmental, resource-economic, European integration and management factors that determine the direction of agribusiness transformation;
- substantiate the directions and mechanisms of this transformation, aimed at increasing adaptability, environmental sustainability and long-term competitiveness of agribusiness.

3. Materials and Methods

3.1. Information base

The study was based on analytical data obtained from official statistical and institutional sources, including Eurostat (data on mineral fertilizer consumption, 2024), the Ministry of Environmental Protection and Natural Resources of Ukraine (data on the current state and degree of agricultural land degradation, 2024), the State Statistics Service of Ukraine, the State Ecological Inspectorate of Ukraine, the Food and Agriculture Organization of the United Nations (FAO), the national statistical agencies of Uzbekistan and Kazakhstan, as well as data from relevant scientific publications.

3.2. Research methods

The following research methods were employed: the monographic method for reviewing scientific literature; the abstract-logical method for developing the authors' conceptual model of agribusiness transformation and formulating the study's conclusions; the comparative analysis method for assessing the degree of agricultural land degradation in Ukraine relative to other countries; the economic-statistical method for analyzing the dynamics of chemical inputs in Ukraine and EU countries; and content analysis for examining international experience in developing climate-resilient agribusiness models.

3.3. Validity and limitations

The reliability of the study's findings is supported by the use of official statistical and analytical data obtained from the European Commission, the State Statistics Service of Ukraine, the national statistical agencies of Azerbaijan and Kazakhstan, the Food and Agriculture Organization of the United Nations (FAO), and the relevant Ukrainian ministries and government agencies responsible for environmental protection. These data enabled a comparative assessment of environmental challenges affecting agriculture across the selected countries.

The main limitation of this study is the ongoing military conflict in Ukraine, which restricts the opportunities for empirical validation and practical implementation of the proposed agribusiness transformation model.

4. Results

4.1. Modern Climate Challenges to Agricultural Development

Active human anthropogenic activity, military conflicts, and the intensification of all types of economic activity have led to large-scale climate changes that exert an increasing impact on agriculture and agribusiness. As a result, the consequences of climate change have already caused a higher frequency of natural anomalies, agricultural soil degradation, the destruction of eco-agrosystems, and alarming rates of biodiversity loss. Research findings by Nunes et al. (2025) demonstrate that climate change has altered the biological life cycle of all biological assets and the nature of their response to the economic activities of agricultural producers - ranging from shifts in crop yields and productivity to reduced resilience of biological assets to all chemical agents. Virtually all scientists and intergovernmental organizations reach the shared conclusion that continuing to use traditional agricultural production models and methods poses a significant threat to global food and environmental security, while also presenting challenges to achieving the goals of sustainable societal development (Albert et al., 2023). There is a broad scientific consensus that sustainable agricultural practices involve increased levels of risk, necessitating the development of new mechanisms to mitigate environmental risks. Furthermore, the implementation of environmentally sustainable agricultural practices requires substantial funding and is characterized by significant regional differentiation across the globe. This existing imbalance leads to a substantial gap in farming models and their outcomes - today, climate-resilient and environmentally safe agricultural technologies cover no more than 35% of the world’s agricultural land (Lu, 2024). Financial provision currently stands as one of the key limiting factors on the path toward greener agriculture. Active state financial support for the environmental transformation of agribusiness should serve as one way to resolve this issue (Barbosa, 2024). Mambo et al. (2025) propose consolidating the efforts of governments, businesses, and non-governmental organizations to identify funding sources that support environmental transformations and sustainable solutions in agriculture. As empirical research by Hultgren et al. (2025) has demonstrated, growth in farmers' income enables them to better respond to the impacts of climate change and take measures to prevent them. The overall result of such actions is the minimization of the negative impact of production activities on the natural environment.

Evaluating current environmental problems in agricultural production faced by producers at the regional level, Wang et al. (2026) highlight the following across the post-Soviet economic space: Central Asian countries (Uzbekistan, Kazakhstan) suffer from water resource depletion, soil degradation, and pollution; Eastern European countries (Ukraine) face soil degradation, biodiversity loss, the trend toward monoculture farming, and the environmental consequences of military conflict; while Western and Central European countries experience soil erosion, loss of organic carbon, and high chemical content in the soil. Such climate changes generate strategic risks for the sustainable development of society on a global scale, manifesting in reduced agricultural and food production, risks to the stable development of rural areas and their social component, as well as risks of direct losses of natural and biological resources, which threaten the existence of future generations (Fanzo et al., 2018).

Ukraine is an important participant in global food chains and one of the world's leading exporters of sunflower oil, rapeseed, corn, wheat, honey, and poultry. As one of the European countries, it has joined global initiatives aimed at minimizing the effects of climate change and achieving sustainable development goals. To continuously monitor the results of achieving climate neutrality goals in Ukraine, a digital SDG platform has been created and is operating. Despite certain actions towards achieving climate neutrality, according to the results of the assessment of the Ministry of Environment of Ukraine, numerous problematic aspects in the development of agriculture were identified: soil degradation, reduced crop yields and increased risks of desertification, pollution of water bodies, rapid loss of biodiversity, waste management problems and unpopularity of circular concepts of agri-food production, environmental consequences caused by the military conflict (Environmental problems of Southern Ukraine). The results of climate change are phenological and geographical changes in the location of biological assets, active settlement of their invasive species, increased resistance to drugs used in agricultural production (Ivanyuta et al., 2020); increased intensity of short-term heavy rainfall with simultaneous trends of increasing frequency and intensity of droughts and increasing number and duration of heat waves (Krakovska & Kryshtop, 2024). Tsvihun (2025) adds to the set of these consequences a traditionally high level of intensification of agricultural production, disruption of farming systems, long-term losses of soil fertility, and a shortage of financial resources necessary for technological modernization of agriculture, taking into account the requirements of environmental friendliness and resource conservation.

Ivanov et al. (2024) draw attention to the low growth rates of organic farming in the country. Despite steady demand for organic food products and Ukraine's significant role in the European organic food market, the share of land under organic production does not exceed 1.1%. Further transformation of Ukraine's agriculture toward alignment with the European Green Deal requires addressing several legal issues, among which harmonizing national and European standards, requirements, and taxonomies is currently paramount: introducing requirements for organic production, organic product certification, agroforestry, and land restoration (Obiyukh, 2025). However, according to the authors, the main limiting factor is the slow pace at which agribusiness adopts the values of sustainable development and society understands the need for environmental changes. Traditional management concepts prioritizing short-term financial gain predominate in most Ukrainian agricultural entities (Kryukova et al., 2023). Uncertainty, macroeconomic instability, and war risks heighten the concerns and negative expectations of agribusiness owners, inhibiting the buildup of long-term competitive potential based on greening production. As a result, chemically intensive and resource-heavy production methods oriented toward conventional practices remain the most widespread in Ukrainian agriculture.

The consequences of climate change and intensive agricultural practices manifest in indicators of agricultural soil usability. An assessment of the degree of agricultural land erosion in EU countries showed that the EU average stands at 5.1%, with the highest levels recorded in countries such as Italy (24.4%), Austria (15,3%), Malta (10,6%), and Greece (9,6%) (Eurostat, 2024). Active European initiatives to green the agricultural sector have yielded positive results and a relative stabilization of this indicator—its value decreased over the period 2000–2023.

Assessment of the quality of Ukrainian soils and the degree of their suitability for agricultural production showed that the average indicator fluctuates within 38-69% (Figure 1). Only two administrative-territorial units out of 24 have a high level of agricultural land quality; three regions are characterized by a low level of quality; the rest - by an average level. The maximum deficit of humus, caused by a long-term deficit in the use of organic fertilizers, is 630-810 kg/ha. According to the conclusions of agricultural experts, the highest rates of loss of qualitative soil quality are in territorial units that historically had the highest indicators.

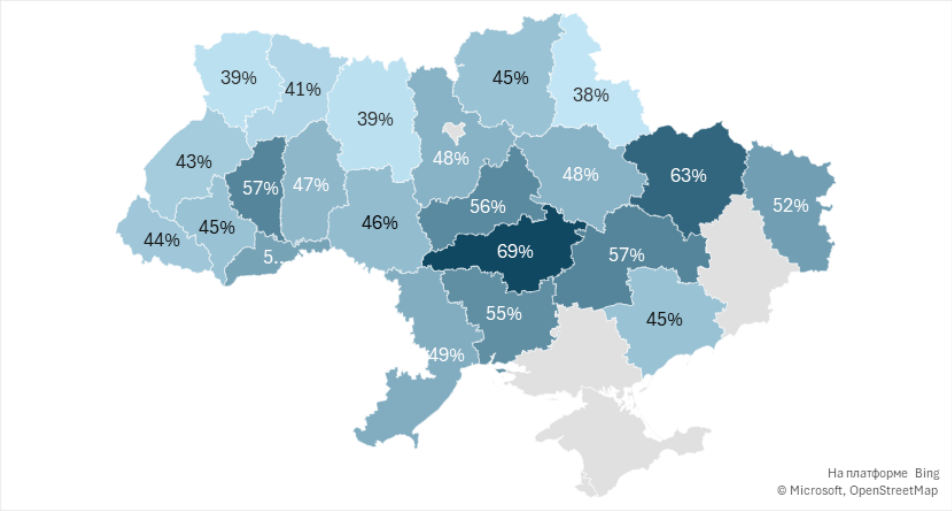


Figure 1. Current state of suitability of agricultural lands in Ukraine, %

Source: constructed by the authors based on data from: Ukraine is catastrophically losing soil fertility (study).

A comparison of actual agricultural land usability indicators with those of selected post-Soviet countries demonstrated that the conservation and restoration of natural land resources is a pressing issue for many nations (Table 1). However, for Ukraine, the rapid acceleration of agricultural land degradation is acquiring an increasingly widespread scale, further compounded by the conditions of military conflict.

Table 1. Comparative assessment of the current state of agricultural land suitability by individual countries

Countries	Main types of agricultural soil degradation	Main indicators
Ukraine	Water and wind erosion, dehumification, heavy metal and explosive contamination, land mining, soil compaction	About 15 million hectares of agricultural land are subject to water erosion; over 6 million hectares are subject to wind erosion; about 20% of Ukraine's territory is at risk of contamination or mining as a result of the war
Kazakhstan	Wind erosion, pasture degradation, desertification, soil salinization	About 70% of the country's territory has experienced land degradation to varying degrees
Uzbekistan	Soil salinization, degradation of irrigated lands, desertification, degradation of pastures	45% of irrigated land is saline; 20% of pastures are degraded; 69% of land has <1% soil organic carbon

Source: Ministry of Environmental Protection and Natural Resources of Ukraine, FAO (2024),
Ecological indicators of environmental monitoring and assessment, FAO SOILS PORTAL, FAO. Uzbekistan

Soil degradation is a consequence of the complex influence of natural and anthropogenic factors, among which erosion processes, depletion of humus state, violation of scientifically substantiated crop rotations, as well as the growing technogenic impact caused by military actions occupy a special place (Tripathi et al, 2020). In order to solve the problem of restoring agricultural lands and minimizing the risks of their degradation, these countries are adopting a complex of policies for the transition to a “green” agroeconomy: “Land Degradation Neutrality” (Uzbekistan), “Climate-Smart Agriculture” (Kazakhstan, Uzbekistan, EU), “Conservation Agriculture”, “National Program for Combating Desertification” (Uzbekistan), RESILAND Central Asia” (Kazakhstan) and others. In Ukraine, to preserve and restore land and resource potential, the National Action Plan to Combat Land Degradation and Desertification, the Strategy for Environmental Security and Adaptation to Climate Change until 2030, and the Strategy for the Development of Agriculture and Rural Areas until 2030 have been adopted.

An important aspect of assessing the environmental sustainability of agricultural production is the level of chemical load on the soil cover, determined by the intensity of mineral fertilizer and plant protection product application. Although the application of mineral fertilizers and plant protection products serves as a key factor in boosting crop productivity, the current agricultural policy of the European Union aims to optimize chemical intensification levels in line with the objectives of the European Green Deal. The European "Farm to Fork" Strategy targets a 50% reduction in the use of chemical pesticides and a minimum

50% reduction in nutrient losses by 2030, which should ensure a decrease in mineral fertilizer application by at least 20% compared to the baseline level (From Farm to Fork). Results of a comparative analysis regarding the impact of chemical input levels on crop yields in EU countries demonstrate that the reduction in mineral nitrogen fertilizer application mandated by EU environmental policy leads to a substantial decline in yield and cannot be implemented through a uniform scenario across all member states. Reducing nitrogen fertilizer use must rely on a differentiated approach that harmonizes the achievement of environmental targets with food security provision (Pacifico et al., 2024). A comparative assessment of chemical input volumes (mineral fertilizers) in EU countries and Ukraine revealed a significantly higher application level in Ukraine. Specifically, the share of land area treated with pesticides during 2020–2024 fluctuates within 93.0–79.6%. At the same time, the chemical load per hectare of cultivated area decreases from 152 kg to 86 kg (Table 2).

Table 2. Indicators of the level of mineral fertilizer application in Ukraine and in EU countries

Indicators	2015	2018	2019	2020	2021	2022	2023	2024
EU countries								
Volume of nitrogen fertilizers applied, thousand tons (average per country)	356,6	346,0	351,5	369,5	359,5	315,8	309,8	327,9
Volume of phosphate fertilizers, million tons (average per country)	38,7	39,8	41,6	43,7	42,0	33,6	31,4	33,8
Ukraine								
Volume of applied mineral fertilizers – total, thousand tons	1415	2151	2142	2489	2584	1832	1400	1298
Share of the crop treated with pesticides (%	81	91	91	93	92	88	87	79,6
Volume of mineral fertilizers, per 1 hectare of area, kg	98	134	131	152	154	144	122	86

Source: calculated by the authors based on data from: Statistical Yearbook of Ukraine (2024), Eurostat (2024)

According to the European Commission, agro-ecological indicators of agriculture during 2023-2024 revealed negative trends, in particular, in terms of increasing the concentration of chemical substances in soils, which creates factors of undesirable pressure on the environment. In Ukraine, increasing the level of applied mineral fertilizers, in particular nitrogen fertilizers, is the main tool for ensuring an increase in the yield of main crops during 2000-2021: the average yield of corn, wheat and sunflower increased by 2.6, 2.3 and 2.0 times, respectively. The increase in the use of phosphorus and potassium fertilizers was also accompanied by a significant increase in yields, with a high coefficient of economic return: increasing the amount of fertilizer application gave a net increase in yields of 3.2 and 1.8 times for winter wheat and 5.8 and 4.2 times for corn (Medinets et al., 2025). Despite the trend of increasing the volume of mineral fertilizers, about 90% of all soils are characterized by a low level of readily hydrolyzable nitrogen. At the same time, the increase in the level of chemical intensification of field production in Ukraine is accompanied by a simultaneous exacerbation of the problem of loss of organic matter and the growing scale of soil erosion. The main causes of soil erosion are the violation of scientifically based norms of the agricultural system, the dominance of commercial monocultures, and the rejection of intercropping, which increases the risks of water and wind erosion (FAO. Ukraine, 2014). The assessment of the quality of agricultural land showed that the loss of humus in Ukrainian black soils occurs on 43% of all areas. In addition, 11% of agricultural land is subject to problems of pollution by chemicals, 4% - problems with salinization and alkalization. The average rate of humus loss in soils is 0.5 t/ha. Based on the results of a comprehensive analysis of the chemical state of agricultural soils in Ukraine, scientists conclude that their current state poses long-term threats to the sustainable development of crop production, the country's ecological security, and global food security (Medinets et al., 2025).

The findings indicate that Ukraine's agricultural sector is undergoing a gradual transformation of its traditional production intensification model. High application levels of agrochemical inputs remain an important factor in maintaining crop productivity; however, the tightening of environmental requirements in line with European Green Deal policies creates the need to optimize their application volumes. The

effectiveness of traditional technologies is also increasingly determined by the impacts of climate change, which are becoming one of the primary factors in agribusiness management. These factors must be taken into account when constructing a modern model of agribusiness transformation, among which the following should be highlighted: accelerated degradation of soil resources in Ukraine, escalating moisture deficits and rising drought risks, declining efficiency of traditional farming technologies, a progressive increase in demands for greening agricultural production according to the country's European integration course, as well as heightened uncertainty and growing operational risks.

4.2. Military challenges and their environmental consequences for Ukrainian agribusiness

The ongoing military conflict in Ukraine has become an additional factor exacerbating existing environmental challenges. Its consequences are large-scale pollution and mining of agricultural lands, soil deterioration, loss of biodiversity, disruption of the water regime, pollution of surface and groundwater, increased risks of erosion processes, ecosystem degradation, and increased greenhouse gas emissions. The combination of these changes leads to a decrease in the productivity of agro-ecosystems, a reduction in agricultural production, a deterioration in the quality of land resources, and requires the implementation of climate-oriented and environmentally sustainable models of agribusiness management. According to the estimates of the State Ecological Inspectorate of Ukraine, the total amount of losses and damage caused to the country's natural environment as of 2025 is estimated at 85.1 billion US dollars, of which about 32% falls on land resources – 24,1 thousand km² of area has been polluted and littered (Figure 2). The scale of damage is determined by the sphere of plant and animal production, the volume of environmental damage of which is estimated at 23,5 billion US dollars.

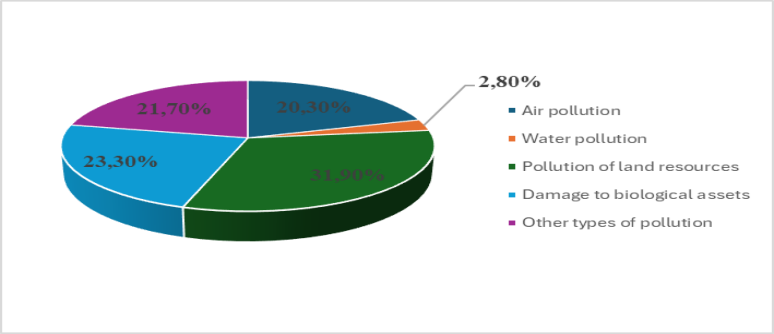


Figure 2. Structure of environmental damage by pollution areas in Ukraine, %

Source: constructed by the authors based on data from: (State Ecological Inspectorate of Ukrainy)

The decline of the Kakhovka HPP was a man-made disaster for the natural environment, which has a direct impact on agriculture. The total area of flooded territories was 612 sq km, which led to the loss of water agro-irrigation potential on the territory of 1,5 million hectares; 64 thousand hectares of forests were flooded. Due to its scale, the volume of biodiversity loss as a result of the Kakhovka disaster has not been finally estimated. The total amount of damage to the environment is estimated at 14 billion US dollars (Kolodezhna & Vasilyuk, 2025). For the sphere of agricultural production, the consequences of the military conflict were manifested both in direct form and in the form of the loss of potential income of agricultural producers. The total amount of economic losses, according to expert estimates, is 80 billion US dollars, of which direct losses account for almost 11% (8.7 billion US dollars). The maximum damage was caused by a decrease in the production of annual crops - over 34.3 billion USD- which caused additional losses due to reduced exports and domestic prices in the amount of 24.1 billion USD. Direct costs in the livestock sector are estimated at 5.6 billion USD (UFRD, 2025).

The military conflict in Ukraine has significantly amplified the negative impact of climate change on the agricultural sector, generating a complex set of interconnected environmental and economic risks. Soil degradation, land and water resource contamination, land mining, destruction of irrigation and drainage infrastructure, biodiversity loss, and disruptions to natural ecosystems reduce the productivity of

agricultural landscapes, elevate production costs, increase investment risks, and limit opportunities for the efficient use of agribusiness resource potential. Under such conditions, environmental losses transform into direct economic damage for agribusiness and heighten its vulnerability to climate change impacts through declining yields, rising production costs, loss of land capital, the need for natural resource restoration, and reduced competitiveness of agricultural entities. In this context, traditional agribusiness transformation models no longer provide an adequate level of resilience, necessitating a transition toward adaptability, climate resilience, environmental safety, and risk-oriented management.

4.3. Directions of agribusiness transformation in the context of climate change and military environmental challenges

Climatic and environmental challenges for Ukrainian agriculture, which have intensified under the conditions of military conflict, have led to an objective understanding of the need for a comprehensive transformation of agribusiness. The findings of this study enabled the systematization of the main strategic climate-related and military-environmental challenges affecting agribusiness and requiring appropriate management responses (Table 3).

Table 3. Strategic challenges of agribusiness transformation in the context of climate change and military-environmental challenges

Strategic challenges	Main content	Implications for agribusiness
Military-environmental challenges	Mining of agricultural lands, contamination of soils, surface and groundwater with explosion products, heavy metals, and fuel and lubricants, destruction of land reclamation and hydraulic infrastructure, damage to natural ecosystems	Withdrawal of land from economic use, loss of part of the resource potential, increase in costs for demining, reclamation and ecological restoration, decrease in the investment attractiveness of agribusiness
Climate challenges	Increase in average annual temperature, change in precipitation patterns, increase in frequency of extreme weather events, water supply shortage	Decrease in agricultural yields and productivity, increased business risk, increased costs for adaptation measures, increased climate risks
Environmental challenges of sustainable nature management	Soil degradation and erosion, reduced soil fertility, reduced biodiversity, limited water resources, excessive anthropogenic load	Decline in natural land productivity, increased costs for maintaining soil fertility and restoring natural and biological resources
European integration environmental challenges	Strengthening EU environmental requirements, implementing the European Green Deal, introducing ESG principles and decarbonizing agricultural production	The need to modernize production, invest in the greening of agribusiness, and increase requirements for the environmental quality of products and competitiveness
Resource and economic challenges	Rising prices for material and technical resources, disruption of logistics chains, shortage of labor and financial resources, high market and macroeconomic uncertainty	Growth in production costs, reduction in the financial stability of enterprises, reduction in investment activity. Growth in economic risks of agribusiness
Management challenges	The simultaneous impact of climatic, military-ecological, environmental and economic factors that change the conditions for the functioning of agribusiness	The need to transition to adaptive, risk-based, climate-resilient and environmentally sustainable management models

Source: compiled by the authors

The totality of these challenges necessitates shifting traditional approaches to agribusiness transformation toward the search for more sustainable environmental models capable of ensuring the long-term competitiveness of Ukrainian agricultural products in both domestic and global markets. Among such models, Chinese scientists propose a conceptual model for ecologically sustainable agribusiness development based on the "Drivers-Pressure-State-Impact-Response" framework, aimed at achieving multi-objective optimization of agricultural activities. Scientists highlight subsidies, carbon trade quotas, preferential "green loans," and other forms of state support as key drivers for its implementation into farmers' practical activities (Wang et al., 2026). As central mechanisms for minimizing climate change impacts within the agribusiness model, Zhang S. et al. emphasize digital finance and supply chains, which

influence final results as well as the economic, environmental, and social sustainability of agriculture through cost management (Zhang, 2025). Ukrainian scholars are likewise working toward identifying effective environmentally oriented models for agribusiness transformation, agreeing that innovation—particularly digital innovation—must serve as their core (Borysiak, 2025). In previous studies, the authors have already demonstrated that without the digitalization of agricultural production, artificial intelligence technologies, and integrated digital platforms, the establishment of climate-resilient agribusiness is hardly feasible (Linde et al., 2024; Zamlynskyi et al., 2024; Shabatura et al., 2025). Food and energy security, rural revitalization, and the building of long-term competitive potential for agribusiness based on sustainable development principles should serve as strategic benchmarks for transformation models (Yermolenko, 2026). Although the authors generally agree on the strategic approaches to agribusiness transformation, they consistently identify limited financial resources as the main barrier to its effective implementation. In the authors' agribusiness transformation model, securing the financial resources required to address environmental challenges involves capital accumulation through funding source diversification, the use of digital financial instruments, and the attraction of green investments and grant programs grounded in ESG-oriented financing. Thus, the proposed model focuses on creating conditions for the inclusive expansion of agricultural enterprises' financial potential. Digitalization serves as the primary tool facilitating such inclusive access for agricultural producers to capital markets and agro-ecological innovations (Figure 3).

This approach builds upon the authors' previous research, which identified the digital transformation of agricultural production, digital platforms, and artificial intelligence technologies as key tools for enhancing the agricultural sector's adaptation to climate change (Zamlynskyi et al., 2024; Linde et al., 2024; Shabatura et al., 2025). The authors consider digital technologies and solutions as one of the most powerful tools for adapting agriculture to climate change and implementing sustainable methods of agricultural activities. In world practice, digital solutions have strong potential for implementation in all branches of agricultural production (crop production, livestock farming, auxiliary production), work in real time, and contribute to the creation of sustainable agricultural value chains. In the context of adapting agribusiness management to environmental challenges and preventing the consequences of climate change, Finger (2023) divides digital solutions into five main groups: geoinformation technologies, diagnostic tools, applied tools, automated production processes and technological systems, and data networks. Ukraine is characterized by high rates of digitalization of socio-economic relations, in particular, in the field of agricultural production. Similar conclusions regarding the role of digital transformation, the platformization of the agricultural sector, and the application of artificial intelligence technologies in enhancing the adaptability of agribusiness to climate change were reached in the authors' previous studies (Zamlynskyi et al., 2024; Linde et al., 2024; Shabatura et al., 2025). In recent years, in general, an infrastructure for digital transformations of agribusiness has been created, the main elements of which are the digital platform DAR (State Agrarian Register) with relevant analytical modules, the Unified State Platform of Agricultural Knowledge and Innovations AKIS, the unified electronic system "eCrop Production", and the State Register of Environmental Impact Assessment. Local management platforms AgroOnline, Soft.Farm, AgroOffic, Cropio and others are being introduced into the practical activities of agribusiness. These architectural components contribute to the gradual transformation of agribusiness management systems towards increasing the level of climate neutrality and environmental sustainability. The central aspect of the implementation of environmental initiatives of Ukrainian agribusiness remains the financial capacity to ensure environmental transformations. In modern realities, the potential of the Ukrainian financial segment is in a state of stagnation due to geopolitical conflicts and macroeconomic instability. The main financial source of most agricultural structures in Ukraine remains equity. Increasing the level of accessibility and inclusiveness of external financial resources for Ukrainian agricultural producers is currently the leading task of digital infrastructure and a prerequisite for the implementation of climate-oriented solutions in agriculture. In this context, one of the key areas of further development of the country's digital infrastructure should be the

creation of an integrated digital financial system for the agricultural sector and technologically related activities, the key function of which is to ensure inclusive access of agricultural entities to financial capital markets.

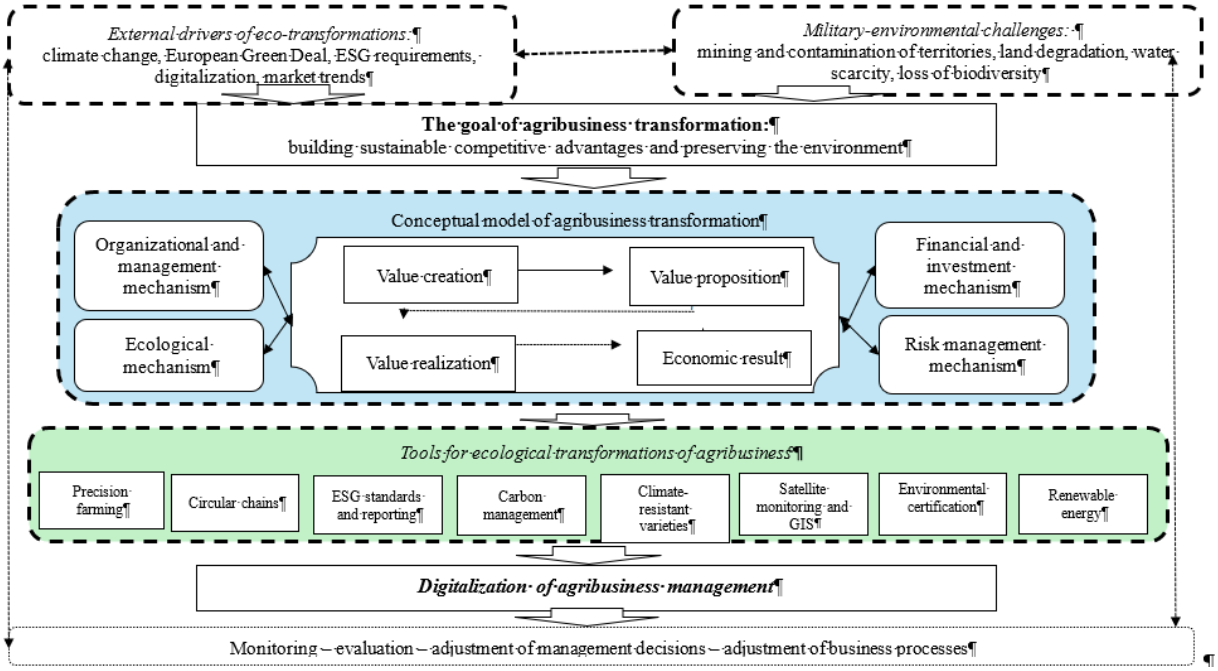


Figure 3. Model of agribusiness transformation in the context of climate change and military environmental challenges
Source: author's development

5. Discussion

A review of global practice in substantiating agribusiness transformation models under climate change has shown that, despite sound methodological approaches, existing models remain limited in terms of transformation scale and national implementation specifics. Most models focus on optimizing management decisions to achieve sustainable development across all its dimensions: environmental, economic, and social sustainability. However, research efforts are predominantly directed toward mitigating (reducing) the impacts of climate change in agribusiness, with less emphasis placed on their prevention. While conceptually agreeing with the sustainable agribusiness development model proposed by Wang et al. (2026), the authors consider the aspects regarding the outcomes and strength of digital finance's influence on climate change impacts to remain open for discussion. Practical agribusiness transformation models based on climate neutrality and sustainable development developed in EU countries often account for small farm sizes, creating limitations for Ukrainian practice where farm sizes are frequently larger (Pret et al., 2025). At the same time, the methods proposed by scholars to build models resilient to environmental challenges remain highly relevant for Ukraine: crop diversification, waste reuse, and the organization of inclusive supply chains within rural areas (De la Parra-Guerra et al., 2026). For Ukraine, the main limitation of these models remains their failure to account for the impact of the military factor, which amplifies environmental challenges and exerts a long-term influence.

6. Conclusions

The findings indicate that Ukrainian agribusiness currently operates under the combined pressure of climate change, degradation of natural resources, the chemical intensification of agricultural production, and the far-reaching consequences of the ongoing military conflict. It is the combination of these factors,

and not any one of them, that forms new business conditions and requires a revision of traditional approaches to management.

Climatic and environmental changes are most noticeably manifested in soil degradation and erosion, loss of humus, reduction of biodiversity, increasing risks of desertification and shortage of water resources, and traditional farming technologies are increasingly failing to cope with their function. A comparison of the state of agricultural lands in Ukraine with Kazakhstan and Uzbekistan shows that this is not a local, but a systemic problem that requires both state and corporate recovery measures.

The intensive use of mineral fertilizers and plant protection products remains a key driver of crop productivity in Ukraine. However, it also increases environmental pressure on soils. In the context of European integration, this requires a shift from maximizing input volumes to the more differentiated, science-based, and environmentally sustainable use of agricultural resources.

The ongoing military conflict has further exacerbated these problems. Mining and land pollution, destruction of land reclamation and hydrotechnical infrastructure, violation of the water regime, loss of biodiversity and damage to ecosystems — all this reduces the resource potential of agribusiness, increases production costs, reduces investment attractiveness and makes the prospects for long-term recovery less certain.

Accordingly, the study systematizes the key groups of challenges shaping agribusiness transformation, including military-environmental, climate-related, environmental, European integration, resource-economic, and management challenges. The findings demonstrate that these challenges can only be effectively addressed through the transition to adaptive, risk-oriented, and climate-resilient management models.

The study develops a conceptual model of agribusiness transformation that integrates organizational and managerial, environmental, financial and investment, and risk management mechanisms. Its practical implementation is based on precision agriculture, satellite monitoring and GIS technologies, circular supply chains, ESG standards and reporting, carbon management, environmental certification, renewable energy and digital management tools.

The practical value of the proposed approach lies primarily in the fact that agricultural enterprises can use it to form their own adaptive management decisions, more effectively use natural resources and access green financing, and therefore strengthen long-term competitiveness. Further research should be directed at developing a system of indicators for assessing the effectiveness of such a transformation and at testing the proposed model directly at the level of agricultural enterprises and regional agri-food systems.

Author Contributions

The sole author is responsible for conceptualizing, collecting, and analyzing data, and writing and editing the manuscript

Conflict of Interest

The authors declare no conflicts of interest

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