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The agriculture of Ukraine amidst war and agroecology as a driver of post-war reconstruction

This paper reveals the nature and extent of the damage inflicted upon Ukraine's agrarian sector by Russian military actions, as well as the pre-existing deficiencies that have adversely affected its functioning during wartime. Proposals from governmental institutions, researchers, agricultural producers' associations, and civil society may be categorised into three potential post-war reconstruction scenarios: maintaining its pre-war predominantly raw model, enhancing investment attractiveness, and strengthening the orientation towards sustainable development. The potential consequences of implementing each identified model for economic entities in agriculture and for society in the progression towards European Union membership have been outlined. This paper contends that transition towards development based on contemporary (innovative) principles of agroecology is essential for creating resilient local and, consequently, national agricultural and food systems. Meanwhile, the role played by different categories of agricultural producers utilising agroecological practices in enhancing the resilience of agrifood systems and the main directions for promoting the dissemination of these practices have both been revealed. The practical significance of the research results involves the possibility of their implementation in developing a coordinated version of the post-war reconstruction and the further development of Ukraine's agrarian sector, the defining feature of which should be an approach that aligns with the principles of the EU's Common Agricultural Policy, further incorporating a transition to agricultural development based on agroecology.

Keywords: agri-food sphere, losses of the agrarian sector, directions of post-war development, European Integration, organic production

JEL classifications: O13, Q18, Q28

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Introduction

The full-scale Russian war against Ukraine has dramatically changed the development of all spheres of human life and triggered an economic decline in most sectors of the national economy. The losses incurred by the agricultural sector are significant and specific due to the territorial attachment and impossibility of physical relocation of business, withdrawal of agricultural land from cultivation caused by mining, contamination with chemical elements, mechanical deformations, and other related factors. Challenges and uncertainties have also been caused by the disruption of logistics chains, including the blockade of the Black Sea ports, resulting in significant export complications, physical destruction of elevators, machinery, livestock, and shortages of fuel, fertilisers, and pesticides. The extreme conditions have also revealed the shortcomings of the national agricultural system that came into existence during the transition from an administrative command to a market economy. These include the dominance of large-scale corporate enterprises and their associations (agroholdings) with a focus on raw exports, and the marginalisation of the family-farming type of economy.

Taking into account the role of agriculture in guaranteeing the national economic and food security and the well-being of almost a third part of the country's population, as well as the prospects of Ukraine's accession to the European Union, post-war development within the sector will require, along with financial resources, effective decisions that will not only restore its potential but also set the foundations for its restructuring. The raw model of agricultural development should be changed to a value-added model coinciding with the dissemination of ecologically sound farming practices to provide people with safe and high-quality food, strengthen the competitiveness of agricultural producers and enhance the sustainability of local and national agri-food systems.

The purpose of the paper is to characterise the losses and lessons of wartime for Ukraine's agrarian sector, outline probable scenarios for its post-war reconstruction, and substantiate the necessity of further development based on agroecology principles.

Literature review

During the ongoing Russian military aggression in Ukraine, opportunities for the efficient functioning of economy are being explored with the overarching objectives pointing towards ensuring food security and sustaining the financial resilience of the country. Concurrently, directions and pathways for its post-war development have been considered. The impact of hostilities on the agri-food sphere of Ukraine, as well as the challenges and prospects of its post-war reconstruction appear in a variety of publications. Mamonova *et al.* (2023) provide a thorough analysis of Ukrainian agriculture, consequences of hostilities for different categories of producers, intentions of the authorities, proposals of researchers and representatives of civic society for its post-war development. The objectives of national food security, risks of the wartime period and post-war pathways to achieve these objectives are outlined by Shubravska and Prokopenko (2022). Ibatullin *et al.* (2022) present a mechanism for assessing economic damages inflicted on farmland, necessitating demining and restoration of

its suitability for safe food production. Cherevko (2022) delineates the losses incurred by Ukrainian agriculture and emphasises that the post-war recovery of the agrarian sector should be based on innovative principles and funded through the state budget and assistance from international organisations. A crucial factor for macroeconomic stabilisation, he contends, lies in boosting agricultural exports to sustain foreign exchange reserves and ensure the stability of the national currency.

Researchers also simulate development plans for the agrarian sector, drawing on successful steps taken by foreign countries. Taking aside the experience of the Republic of Korea, Nebrat (2022) stresses that post-war agricultural transformation should be oriented towards the development of highly productive family farming, which will contribute to strengthening food self-sufficiency, increasing employment, and expanding the domestic market. Based on the example of Croatia's recovery, Gorin (2022) concludes that economic revitalisation in rural areas is linked to stimulating the development of small-scale agricultural producers. Didkivska (2022), focusing on the achievements of Italy, finds significant opportunities in enhancing capacities for agricultural raw processing, promoting organic farming, and implementing structural reforms, often feasible in the aftermath of particularly challenging crises.

Some of the publications also draw attention to the necessity of adhering to principles of agroecology in the post-war period, particularly emphasising the main provisions of the European Green Deal. Khodakivska *et al.* (2023) also stress the importance of developing a "green" economy, noting that the production of ecologically sound products will have competitive advantages at the national and international levels and will retain the characteristics necessary for production efficiency indicators. The monograph edited by Drebot *et al.* (2023) puts the agroecological foundations of developing sustainable food systems and shapes the market for ecologically safe products. However, organic farming, other forms of ecologically friendly production, and the overall concept of "agroecology" in Ukrainian scientific literature are predominantly examined within the framework of the "natural environment – agricultural production" system (Furdychko, 2017; Shkuratov *et al.,* 2015), while socio-economic aspects of such a system, and the utilisation of agroecology as an innovative approach to ensuring sustainable development receive insufficient attention.

On the whole, assessments of the effects of hostilities on the development of Ukraine's agrarian sphere require more comprehensive synthesis and systematisation, while the determination of pathways for its post-war development, taking into account the benchmarks of the EU Association Agreement and the principles of the European Green Deal, necessitates more detailed elaboration. Given that agroecology is one of the key directions of Ukraine's sustainable development strategy at a time when the country is moving towards full membership in the European Union, and that it also now represents a way to mitigate the damage inflicted by war on farmland and other natural resources, a more complete demonstration of its impact in terms of increasing the resilience of agricultural and food systems is needed. This paper aims to examine these issues and explore ways of addressing them.

Methodology

This study is based on recent data assessment of the impacts of war on Ukrainian agriculture in light of the 17 UN Sustainable Development Goals, adapted to the Ukrainian realities. The information basis of the research includes EU legislation and regulations related to the implementation of the European Green Deal; scientific papers and open data from information sources assessing the losses of the agrarian sector from a full-scale war and its implications for development; statistical data, published information about producers of ecologically sound products, and expert evaluations regarding the distribution of agroecological methods in national agriculture.

Results

Modern agriculture in Ukraine is represented by two groups of producers: agricultural enterprises and farming households. Enterprises are legal entities, including private farms engaged in systematic agricultural production. As of early 2024, 73.9 thousand enterprises had been registered (State Statistic Service of Ukraine, 2024c), of which 50.1 thousand private farms (State Statistic Service of Ukraine, 2024b). However, only 39.9 thousand enterprises were recorded as active, meaning they carried out economic activities (for comparison: in 2021, there were 46.2 thousand active enterprises) (State Statistic Service of Ukraine, 2024a). A significant portion of agricultural enterprises are part of vertically integrated structures (agroholdings). According to the National Scientific Centre "Institute of Agrarian Economics NAAS", in 2022, the number of large enterprises in the industry (over 250 employees, annual income equivalent to 50 million euros) decreased by 20.4%, medium enterprises by 19.5%, small enterprises (up to 50 employees, income up to 10 million euros) by 31.8%, and microenterprises (up to 10 employees, income up to 2 million euros) by 34.5% (Lupenko, 2023).

Farming households are those who engage in agricultural activities both for self-sufficiency in food and for the production of marketable agricultural products. This category of producers also includes individual entrepreneurs conducting agricultural activities[1]. In the pre-war period, 98% of households had land plots (State Statistic Service of Ukraine, 2018), 26% kept cattle, 37% pigs, and 96% poultry (State Statistic Service of Ukraine, 2021).

The dynamics of gross agricultural production by categories of producers show a gradual increase in the share of enterprises. In 2023, the volume of output produced by agricultural enterprises amounted to 68.5% (Figure 1).

Agricultural enterprises, particularly those within agroholdings, possess (or lease) significant land areas, modern agricultural machinery and developed infrastructure for processing and storing products for subsequent sale primarily on global agri-food markets. To achieve their goals, they often engage in monoculture production and intensive technologies, which contradict the requirements of ecologically sound farm-

[1] The article presents data provided by the State Statistics Service of Ukraine, according to which agricultural enterprises and farming households represented as two groups of producers. In fact, Ukrainian agriculture is divided into large industrial agribusinesses, including agricultural enterprises, and small producers, consisting of small and medium-sized family farms and peasant farms.

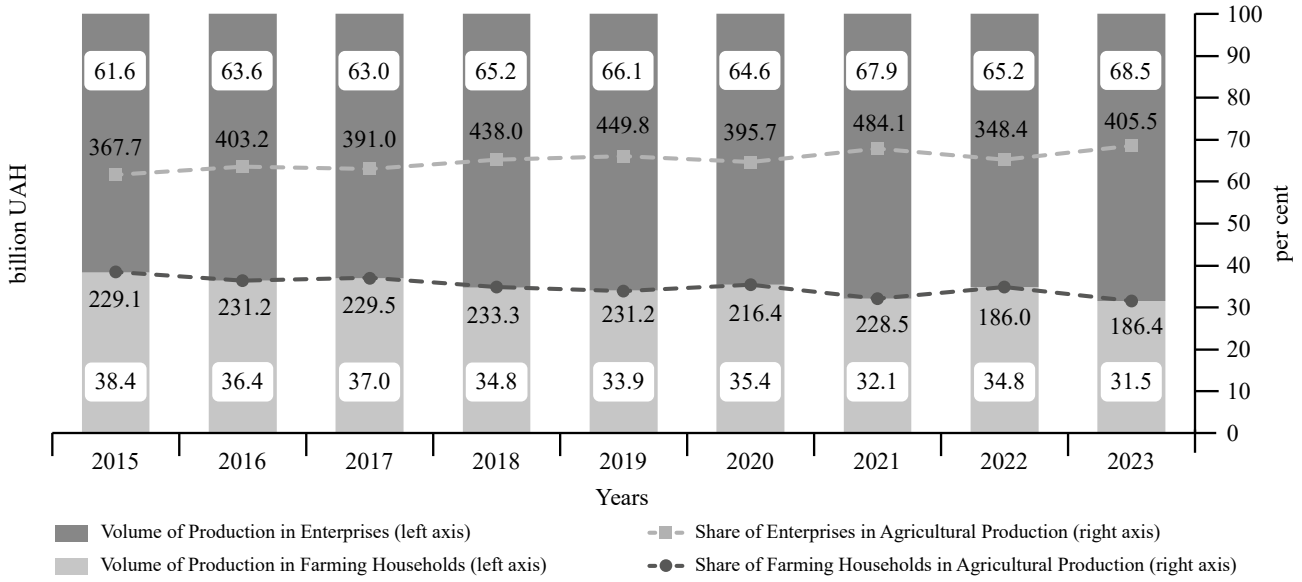

Figure 1: Agricultural output by category of producers.
Source: own composition based on data from the Statistical Yearbook "Agriculture of Ukraine" for the respective years

ing. Farming households are mainly oriented towards meeting the country's internal food needs. They are characterised by the sustainable use of natural resources, preservation of biodiversity, and the application of circular economy elements.

Consequences of military actions

The Russian invasion of the territory of Ukraine resulted in a colossal destructive impact on agriculture: according to World Bank estimates as of the end of 2023, the total losses incurred by the agrarian sector amounted to $10.3 billion. Within this structure, the largest share (56.7%) pertains to fully or partially destroyed machinery and equipment; 18.2% corresponds to looted produce from storage facilities, and 17.5% accounts for lost grain storage capacities. Other losses include destroyed perennial plantations, livestock, and beekeeping resources, stocks of mineral fertilisers, plant protection products, fuel and lubricants and more.

Agriculture suffered losses totalling approximately $69.9 billion due to foregone revenues resulting from reduced production volumes, decreased domestic prices for agricultural products, increased costs of resources engaged in production processes, etc. (including losses from the detonation of the Kakhovka Hydroelectric Power Station) (Himmelfarb, 2024). These include reductions in the production volumes of annual crops (49.2%), decreases in domestic prices for primary agricultural products (35%) and reductions in livestock production volumes due to herd reductions and decreased productivity (8.1%).

Furthermore, as of the beginning of 2024, the area of agricultural land available for use in production activities has decreased by 20.3% (Nikoliuk *et al.,* 2024). The area of land abandoned due to the proximity of combat operations ranges from 2.1 to 2.8 million hectares, constituting 6.5 to 8.5% of the total arable land area in Ukraine. According to NASA Harvest estimates, in 2023 alone Ukraine suffered about $2 billion in economic losses due to the loss of crops on fields that had already been sown. Given the conditions for harvesting, the yield obtained would have been sufficient to feed 25 million people for a year (HARVEST, 2023).

The detonation of the Kakhovka Hydroelectric Power Station has resulted in the inundation of tens of thousands of hectares of agricultural land. Such soils are expected to continue degrading due to the gradual re-moistening of drained lands, siltation, and wind erosion. Desertification is possible in some areas. Presently, 94% of irrigation systems in the Kherson region, 74% in the Zaporizhzhia region, and 30% in the Dnipropetrovsk region lack water supply. Over 400 thousand hectares of land remain without irrigation (UkrInform, 2023).

Soil pollution, manifesting as changes in soil structure, physical characteristics, and physicochemical parameters, should be considered a distinct component of the inflicted damage. Experts from the Ministry of Environmental Protection and Natural Resources of Ukraine estimate its cost at $18 billion (Government Portal, 2023). According to the Ukrainian Environmental Organisation, nearly one-third of the territories in Ukraine could be contaminated with munitions and hazardous substances, with significant impacts observed in the southern and eastern regions of the country (Man'ko, 2023).

In the medium and long term, the agrarian sector will face the reduction of sown areas, shifts in crop rotation models, a decrease in livestock numbers, disruption of supply logistics chains, destruction of sales networks, and a significant reduction in the workforce due to mobilisation and migration leading to the loss of highly qualified specialists, carriers of unique knowledge and skills, and the destruction of social and human capital. However, the Ukrainian agrarian sector has generally demonstrated the ability to recover relatively quickly. Currently, the production of agricultural outputs is gradually increasing: the agricultural production index in 2023 exceeded the corresponding figure for 2022 by 36.4 percentage points, including crop production by 42.1 percentage points and livestock

production by 12.2 percentage points. Evidently, the pace of agricultural recovery is accelerating - however, the volume of production in 2023 amounted to only 83.1% of the pre-war level.

At the same time, the existing model of agriculture's functioning in the context of wartime has demonstrated a lack of resilience and adaptability to the war challenges and sudden changes in the economic environment. The severe destructive impact of hostilities has demonstrated the vulnerability of long supply chains that rely on stable, optimal logistics systems, as well as the low mobility and overly rigid specialisation of large agricultural enterprises, which predominantly focus on cultivating grain and oilseed crops for export.

A significant imbalance exists in the areas of agricultural production. In 2021, the share of crop production in the total volume comprised 86%, while the volumes of livestock production have been continuously decreasing: from 2010 to 2021, the number of cattle decreased by 53%, cows by 49.5%, pigs by 65.5%, and sheep and goats by 62%. This differs significantly from the structure of agricultural production in the EU, where 57% of the production is attributed to crop farming and 43% to livestock farming, with a high share of dairy and pig farming (Gadzalo, 2023).

The prolonged prioritisation of large agricultural enterprises within the framework of state agrarian policy, the lack of financial resources among small producers, challenging competitive conditions, the absence of a comprehensive approach to organising state support, its sporadic nature have led to the fact that small producers in the pre-war period were unable to accumulate sufficient resilience and robustness to contemporary challenges.

The results of a survey conducted by the United Nations Food and Agriculture Organisation (FAO, 2023) show that the total estimated losses for agricultural enterprises cultivating up to 250 hectares are valued at $3.85 billion in both the crop and livestock sectors; the income for nearly 90% of small crop producers have significantly decreased, with more than 70% experiencing reductions of nearly a quarter; the income for 60% of small livestock producers decreased, while their debt obligations significantly increased. Meanwhile, human development history shows that the institution of self-sufficiency becomes critically important during periods of heightened crisis. From this perspective, small producers are most oriented towards the development of this institution. Immediately following the Russian invasion, they provided food security for local communities, while state food security required a global transformation of logistics chains, reorientation of commodity flows, and the implementation of new mechanisms for product realisation to ensure food supplies for people. Small producers have convincingly demonstrated their significant role in ensuring food security and thus should become the focus of active state support.

Post-war reconstruction of the agrarian sector

Since 2022, representatives from academia, government, and civil society have been working on developing post-war reconstruction plans for the country, including the agrarian sector. In the draft Strategy for the Development of Agriculture and Rural Areas until 2030, presented by the Ministry of Agrarian Policy and Food of Ukraine, emphasis is placed on the need for changes in the implementation of state agrarian policy. These changes are particularly related to granting Ukraine candidate status for EU membership and other international obligations, which will contribute to achieving overall economic, ecological, and social goals following Ukraine's Plan for implementing the Ukraine Facility programme (Ministry of Agrarian Policy and Food of Ukraine, 2024b).

Researchers at the Ukrainian Academy of Agrarian Sciences believe that the post-war reconstruction of agriculture should not only restore production volumes and address the damage inflicted but also ensure structural transformations for the further agricultural and rural development of Ukraine. Researchers highlight the key components of state policy formation in the agri-food sphere, which include self-sufficiency, financial independence, economic and physical accessibility, quality, social and health effects, and stability (Gadzalo, 2023). Representatives of small agricultural producers and civil society organisations, in turn, emphasise the need to establish the family farm model of governance in the legal framework, focusing on the necessity of enhancing the protection of peasant land rights in Ukraine and ending the over-concentration of agricultural lands in the hands of individuals and interest groups as private property (URDN, 2023).

Considering Ukraine's European prospects, the post-war reconstruction of its agri-food sphere should be oriented towards the Common Agricultural Policy of the European Union (CAP). The European Green Deal has been identified as one of the main strategic directions of development, which is subordinated to current changes in various sectors of the economy. Measures to achieve the objectives of the Green Deal in agriculture are specified in strategies such as "Farm to Fork" (F2F), "Biodiversity 2030" and "Soil Strategy for 2030". The common goal of these initiatives is to mitigate the adverse effects of climate change, enhance the sustainability of food systems, preserve and restore biodiversity, and rehabilitate all soil ecosystems in the EU by 2050.

In 2024, due to growing political opposition from farming lobbies and pressure from European farmers, the implementation of certain provisions and specific requirements of the "Farm to Fork" Strategy, particularly regarding the use of pesticides, has been suspended. This suspension will remain until auxiliary measures are developed to protect European farmers from reductions in productivity and income losses (European Commission, 2024). The "convincingness" of the economic justification for measures to protect natural resources is recognised as insufficient, and there is a need for more dialogue and exploration of alternative approaches to move forward (EuroNews, 2024). The European Commission's proposals to restrict the use of plant protection agents have been withdrawn. Additionally, the European Commission has introduced a one-year pause on the requirement for farmers to leave agricultural land fallow to preserve biodiversity. However, the primary focus on creating sustainable food systems in line with the EU Green Deal remains relevant. All this highlights the importance not only of adapting legislation and making appropriate decisions for the

transition to sustainable development but also of conducting vigorous preparatory and explanatory work with the target groups most involved in the process of change.

Ukraine needs to utilise the developments of European policy and apply them as benchmarks for further development. Given this context, the agri-food sphere in Ukraine can be developed in the post-war period according to the following three scenarios (Figure 2).

The first scenario envisions the restoration of the agrarian sector based on pre-war principles, prioritising industrial agricultural production. As a result of its implementation, the volumes of raw production and export will gradually be restored, and, consequently, in the short term, all the negative effects of resource-exhausting export-oriented agriculture with its ecological and social problems will return. The implementation of land reform, particularly its second phase, in which legal entities are granted the right to acquire agricultural land up to 10,000 hectares, will significantly accelerate the concentration of land resources by large agricultural enterprises focused on the export of grain and oilseed crops.

Such an export structure is typical for countries with low income levels. Continuing the raw model in Ukraine will perpetuate income polarisation, enriching the owners of agribusinesses, further depopulating rural areas, and leading to the loss of traditional rural lifestyles in their best manifestations.

The second scenario is aimed at a comprehensive restructuring of Ukraine's agrarian sector transitioning from a raw to a technological development model. This is a costly and time-consuming process, but it will allow the agricultural potential to be utilised for the benefit of society, ensuring economic interests, ecological requirements, and the social needs of the population, and will contribute to strengthening the sustainability of economic development. As noted above, the organisational structure of Ukrainian agriculture is represented by two sectors of producers - enterprises (including holding companies) and farming households. These two sectors differ significantly from each other both in terms of production potential and in terms of market positioning in the agri-food sphere, hence the directions taken by their further development will also differ.

The development prospects for agricultural enterprises lie in the realm of processing. According to expert assessments, deep processing of just five crops (wheat, soy, corn, barley, and rapeseed) would increase the added value share in agricultural production to 28%; and boost export revenue to $41 billion per year (a $30 billion increase); enhance annual tax revenues by 55 billion UAH; and create 26,500 new jobs, thereby generating an overall annual GDP growth of 5% (Batanin, 2022). Achieving such results will require not only significant investments but also an awareness of development prospects among entrepreneurs.

The state can use mechanisms of tax differentiation, additional export duties, and quotas on the sale of raw materials to stimulate the transition from selling to producing and marketing processed goods. In post-war plans, the state should announce the introduction of raw export duty within 5-10 years, coupled with incentives for new processing

Scenarios	Preservation of Raw Model	Establishment of the "Investment Attractiveness" Model	Focus on Sustainable Development Model
Mechanisms	Restoring agricultural production, increasing the volume of export-oriented crops, strengthening control over large scale rent-seeking businesses.	*For enterprises:* production of value-added products, reduction of raw material sales; *For farming households:* inclusion in product sales chains; enhancement of cooperation.	*For enterprises:* production of value-added products, reduction of raw material sales; *For farming households:* inclusion in product sales chains; enhancement of cooperation.
Consequences	Depletion of agro-resource potential for the enrichment of a limited number of business owners, further income polarisation and "conservation" of poverty, aggravation of the labour market situation, and intensification of migration processes.	*For enterprises:* increased efficiency of land use, reduced physical volumes of exports and increased profits; *For farming households:* increased profitability, improved welfare; *For the society:* increased economic activity, employment growth, increased budget revenues	Ensuring the sustainability of food production and agriculture, improving the quality of soil, water, air, preventing climate change, reducing greenhouse gas emissions from agriculture, restoring biodiversity, stopping land degradation, and increasing food sustainability
Role of the state	Neutral-stabilising	Protectionist (incentives and restrictions)	Simulating

Figure 2: Scenarios for post-war reconstruction of the agri-food sphere in Ukraine.
Source: own composition

enterprises. It would also be prudent to review labour tax rates, which significantly influence decisions regarding the establishment of processing systems. Support through diplomacy in opening new markets for processed agricultural goods could also be significantly helpful.

For farming households, the prospects of post-war restructuring involve their engagement in cooperation, inclusion in food supply chains through state orders for budgetary institutions, and opportunities to participate in tenders for product supply, among others. A separate focus should be state support for farming households in the process of acquiring land, through measures that include the provision of preferential loans, partial compensation, and financial and legal support. Expanding the land bank for small producers will enable them to significantly increase agricultural production volumes, which in turn will stimulate processing, the creation of joint ventures, and the establishment of productive interactions with other producers and communities to find new markets.

Under the third scenario, the restoration of the agrarian sector should occur with a primary emphasis on the ecological component, following a series of commitments made by Ukraine in connection with its application for accession to the EU. Participation in the European Green Deal will not only require adaptation of legislation in the ecological sphere but may also increase requirements for agricultural and food products, which could become an additional trade barrier and negatively impact Ukrainian exports (Mission of Ukraine to the European Union, 2021). However, the agroecological transition, as a system of redefining agricultural production aimed at balancing economic, ecological, and social interests by FAO principles (FAO, 2018), is a crucial tool for achieving the Sustainable Development Goals 2030.

The positive social effects of enhancing the ecological nature of agriculture are likely to be accompanied by a reduction in production volumes and an increase in the cost of production, which will affect not only prices but also the export potential. Moreover, the marketing of ecological, including organic, products will require the exploration of new markets, which in the short term could lead to decreased profits for producers. Therefore, enhancing the ecological sustainability of the Ukrainian agrarian sector aligns with the European development vector, but the cost of adhering to additional commitments will require additional financing. Incentives for farm producers to transition to sustainable farming methods and adopt ecological practices should include financial support programmes, favourable credit terms, and institutional assistance in implementing ecologically friendly innovations. Improving access to land for smallholders could be an important factor, given that they hold traditional knowledge about growing plants, keeping animals, preparing seeds, using natural resources, and producing agricultural products in an environmentally friendly way.

Agroecology as a factor in enhancing the resilience of agricultural and food systems

Agricultural and food production based on agroecology is carried out in various forms: organic farming, permaculture, regenerative agriculture, etc., aimed at the economical use of natural resources and minimising the negative ecological impact of agriculture. With the realisation of the importance of agroecology in addressing the issues of overcoming hunger and poverty, strengthening food security, improving nutrition and health, and achieving many other SDGs by 2030, the interpretation of its essence has significantly expanded.

In contemporary understanding, agroecology is an innovative approach to forming sustainable agricultural and food systems, which integrates ecological and social concepts, based on the application of scientific, traditional, and practical knowledge and adhering to the principles of health, fairness, and inclusiveness. It is fundamentally driven by grassroots initiatives and territorial processes, allowing for the consideration of local specifics and prioritising the needs of people (IFOAM, 2019). It is also rightly considered that agroecology is a key element in the balanced development of rural areas (Zielinski, 2021).

All forms of agroecology contribute to enhancing the resilience of agri-food systems. Unfortunately, apart from organic production, there is insufficient information on the prevalence of these forms in Ukraine. According to the monitoring data from the Ministry of Agrarian Policy and Food in pre-war 2021, the area of agricultural land occupied by organic production amounted to 422.3 thousand hectares (1% of the total agricultural land area), including lands with organic status totalling 370.1 thousand hectares with 528 operators of organic production, among them 418 agricultural producers (Ministry of Agrarian Policy and Food of Ukraine, 2024a). Certification of organic producers is performed by 17 bodies: 16 foreign and one Ukrainian – "Organic Standard". Among the operators certified by Organic Standard in 2023, nearly 60% were agricultural enterprises of various legal forms, 9% were family farms, 10% were individual entrepreneurs, and 11% were individuals (Organic Standard, 2021). Among these individuals, beekeepers – producers of honey and other beekeeping products – predominated.

In 2021, Ukraine marketed 9.8 thousand tons of organic products and exported 260 thousand tons (Ministry of Agrarian Policy and Food of Ukraine, 2024a), meaning that over 96 percent of the production was exported. The export predominantly consisted of crop production: cereals accounted for over 100 thousand tons, oilseeds (including soybeans) for 34 thousand tons, fruits for 20 thousand tons, oilcake for 13 thousand tons, and other types up to 10 thousand tons each (Organic-Info, 2022). Moreover, 73% of the organic exports were directed to EU countries (European Commission, 2022).

If the organic segment of Ukrainian agriculture is evaluated based on the proportion of certified land, it is significantly smaller compared to European Union countries. However, in the pre-war period, it grew at rates comparable to the EU average: from 2012 to 2021, the area of organic lands in Ukraine increased by more than 1.5 times (Table 2). During this period, significant increases in organic land areas occurred in Portugal and Croatia – by 3.8 times, France – by 2.7 times, and Bulgaria, Romania, and Hungary – by more than 2 times. Poland was the only European Union country that saw a decrease in organic farming areas, with organic land use decreasing by 16% over the specified period.

As noted, the "Farm to Fork" strategy adopted in Europe aims to increase the area under organic production to 25% by 2030 (European Commission, 2020a). Although the deadline requirements have been softened, the benchmarks remain relevant. Data from Table 1 suggest that several European countries are likely to achieve this target. Specifically, Austria, Estonia, and Sweden had already surpassed the 20% threshold by 2021, with Portugal closely approaching it. Meanwhile, major agricultural nations such as Poland, Romania, Bulgaria, and others have not even reached 5% in organic land use.

However, the area of organic lands can decrease in specific years due to non-compliance with certification requirements, refusal to certify, or other circumstances. In Ukraine, for example, in 2022, due to hostilities, the area of agricultural lands designated for organic production in the transition period decreased to 263.6 thousand hectares (0.6% of the total agricultural land area). However, the implementation of the directions of the European Green Deal, including the development of organic agriculture, is important in the context of Ukraine's further green reconstruction, particularly in the agrarian sector, as well as the country's application for accession to the EU. The enactment of this requires attention from governmental structures, professional associations of producers, and individual economic entities.

Certified producers of organic products in Ukraine are primarily large agricultural enterprises, whose operations are as export-oriented as those of most similar non-organic producers. Some small organic farms, especially those that grow labour-intensive crops such as blueberries and raspberries, as well as individual producers (beekeepers), are also focused on export. The activity of this category of producers primarily enhances the resilience of the global agri-food system.

Table 1: The organic segment of agriculture in the EU and Ukraine.

Countries	Organic crop area			Share of land under organic crop area in 2021 per cent
	2012 thousand ha	2021 thousand ha	2021 to 2012 times	
EU	9,457.9	14,724.3*	1.5	9.1*
Austria	533.2	680.0*	1.3	25.70*
Estonia	142.1	226.6	1.6	22.97
Sweden	477.7	606.7	1.3	20.2
Portugal	200.8	768.8	3.8	19.31
Italy	1,167.4	2,186.2	1.9	16.83
Czech Republic	468.7	548.8	1.2	15.55
Latvia	195.7	302.2	1.5	15.34
Finland	197.8	327.7	1.7	14.45
Slovakia	164.4	249.7	1.5	13.45
Denmark	194.7	303.1	1.6	11.58
Slovenia	35.1	51.8	1.5	10.81
Spain	1,756.6	2,635.4	1.5	10.79
Greece	462.8	534.6*	1.2	10.15*
France	1,030.9	2,775.7	2.7	9.67
Germany	959.8	1,601.3	1.7	9.65
Lithuania	156.5	261.8	1.7	8.91
Croatia	31.9	121.9	3.8	8.26
Belgium	59.7	102.4	1.7	7.48
Hungary	130.6	293.6	2.2	5.81
Luxembourg	4.1	6.9	1.7	5.19
Romania	288.3	578.7	2.0	4.42
Netherlands	48	76.4	1.6	4.22
Poland	655.5	549.4	0.8	3.78
Ireland	52.8	86.9	1.6	2.00
Bulgaria	39.1	86.3	2.2	1.71
Malta	0.04	0.07	1.8	0.61
Ukraine	272.9	422.3	1.6	0.97

Note: in decreasing order of share of land. * = data as of 2020.
Source: own composition based on data from Eurostat (2021a), Eurostat (2021b) and Organic Federation of Ukraine (2024)

Meanwhile, the export-oriented production of organic products contributes to the establishment of sustainable agricultural systems within the country as well. Agricultural enterprises certified as organic adhere to established rules of soil cultivation, seed requirements, animal husbandry conditions, the use of fertilisers, and plant protection products, thereby preserving the quality of natural resources and the environment. They typically practice crop rotation; some combine crop and livestock farming and process their products. The socioeconomic effectiveness of these enterprises lies in their creation of jobs for peasants who, through working on farms, acquire agroecological knowledge that they can apply in their households and disseminate within communities. Some of these enterprises collaborate with research institutions, educational establishments, and local self-governance bodies, thereby promoting and disseminating the principles of agroecology. A portion of the organic products is sold in the domestic market. However, their participation in fulfilling such an important task of agroecology as providing the country's population with healthy, ecologically clean food is limited.

Small agricultural producers and farming households producing organic products are more oriented toward internal agri-food markets and are more fully integrated into the local and national agri-food systems. Some of them undergo certification, while others usually have regular customers and use various forms of short production and distribution chains: their retail outlets, local agri-food markets, mobile trade, online sales, etc. Such relationships are based on trust and usually do not require product quality certificates. Similarly, small producers who implement agroecological practices other than organic farming. According to our estimates, the number of uncertified farms that produce marketable agricultural products for sale using agroecological practices is an order of magnitude larger than that of certified farms, but the area of their land use is an order of magnitude smaller, and the number of people employed in them is roughly the same.

In assessing the reach of agroecology, it should also be acknowledged that in Ukraine the extent to which agricultural and food products are produced by the population for food self-sufficiency (a traditional component of the agri-food system) is significant. In 2021, the share of consumed products from own production in rural households was: potatoes – over 90%, vegetables and melons – 57%, fruits, berries, grapes – 32%, milk and dairy products – 23%, meat and meat products – 28 percent (State Statistic Service of Ukraine, 2022). A significant portion of these products is obtained using agroecological practices, as their producers (who are also consumers) are directly interested in their safety and quality, as well as in the cleanliness of the environment, which is part of their living environment.

Notably, the food self-sufficiency of the population and the activity of small producers of commercial agricultural output and food products during the war positively impacted the resilience of the national agri-food system. The overall size of these two components can be expected to be maintained in the post-war period. At the same time, given changes in the number and structure of the rural population caused by the war, naturally occurring generational change, etc., the ratio between them will shift in favour of commodity production. The agroecological part of these components of the agri-food system must not decrease but should instead increase.

Discussion

The research results presented in the article are derived from a comprehensive analysis of the losses experienced by Ukraine's agriculture and rural areas due to Russian military aggression, scientific studies focused on identifying the directions, methods, and mechanisms for their post-war development, as well as considering the country's European integration requirements and international obligations in the agri-food sphere. The construction of scenarios for their post-war recovery was facilitated by examining the experiences of foreign countries that have faced similar situations both in the distant past (Pinilla, 2012) and more recently (Nebrat, 2022; Gorin, 2022; Didkivska, 2022), and by evaluating contemporary authors' proposals on the driving forces and sources of funding for this process. The recognition of not only the leading role of the state but also the assistance of the global community in the post-war recovery of Ukraine's agri-food sphere is undeniable, indicating that this recovery must take into account current global trends in the formation and functioning of agri-food systems.

According to the first development scenario proposed in the article, attracting significant financial investments, primarily from international institutions, requires aligning national strategies with the requirements of partners willing to invest in agriculture. Development under the second scenario, the "Investment Attractiveness Model", is clear and acceptable to the authorities and is partially supported by them. In contrast, the third scenario, which involves a more extensive use of agroecology to strengthen Ukraine's agricultural and food system, requires the formation of an active state policy to promote its development. This policy should include: transforming the institutional environment for the development of agriculture and rural areas following the modern interpretation of agroecology; integrating agroecological approaches into the strategies, programmes, and development plans of existing forms of agricultural production and food at national and local levels; creating mechanisms to facilitate the development of agroecological practices, particularly among farming households, to increase the production and consumption of ecologically clean products (Borodina and Prokopa, 2023).

The agroecological development of agriculture fully aligns with global trends. Its strategic importance for ensuring food security and supporting small producers in their fight for food sovereignty, particularly in times of crises and other energy, economic, and climate challenges, is highlighted in the works of various scholars (Akanmu *et al.,* 2023; Simon *et al.,* 2020; Altieri *et al.,* 2012). Researchers are exploring ways to support the transition process (Martin *et al.,* 2018; Anderson *et al.,* 2019) and describe effective and already implemented resource-saving practices (Jeavons, 2001). Public movements advocate for the interests of all those involved in agroecology (ViaCampesina, 2015).

Since agroecology is capable of ensuring the resilience and inclusiveness of the agri-food system primarily at the local level, the policy to promote its development should directly address potential producers and consumers of their products – high-quality food and a clean environment. It should consider the EU directives and guidelines on the CAP agroecological orientation and improve its own legal and regulatory framework for the development of agriculture and rural areas based on agroecology. In addition, efforts should also support awareness raising about agroecology as it is understood today, increase the demand for agroecological products among various categories of people, and facilitate producers' access to organic certification. They should also serve to enhance the attention paid to health, education, environmental protection, agricultural policy, and the food authorities, as well as to local self-governments, compliance with food safety and quality requirements, healthy eating, and more. The number of economic entities in the agri-food sphere introducing agroecological practices will then increase.

Conclusions

The Russian war against Ukraine has inflicted significant damage on its agri-food sphere, including extensive destruction of its natural resource potential, production and infrastructure base, and loss of income for agricultural producers. The country's functioning under martial law has also highlighted the lack of resilience and adaptability in this sphere, problems that stem from the country's excessive raw material export orientation, the vulnerability of its long supply chains, imbalances between crop and livestock farming, and the fact that methods of production vary considerably. Another major contributory factor has been the prioritisation of large enterprises and the concomitant marginalisation of small farms.

The direction to be taken by the post-war recovery of Ukraine's agri-food sphere is being elaborated with due regard being paid to the need to eliminate its war losses and adapt itself with a view to European integration. Three scenarios can be distinguished, dominated by proposals for 1) maintaining the raw material model; 2) developing an "investment attractiveness" model; and 3) focusing on sustainable development. Development under the third scenario aligns most closely with the requirements of European integration of Ukraine and will become an effective mechanism for overcoming the challenges of post-war reconstruction. However, its positive societal effects will evidently be accompanied by a reduction in production volumes and will require improvement of the state support system for the agrarian sector.

The post-war development of Ukraine's agri-food sphere based on sustainability needs to be accompanied by its more active greening, including an increase in organic production and the wider introduction of other agroecological practices. This necessitates the formulation of a state policy to support agroecological development, considering the tasks and principles outlined in EU directives, the main principles of the CAP for the new programming period, and UN guidelines. Its implementation should be systemic and aimed at producers of all categories and consumers of food, ensuring improved access to quality and healthy food products and a clean environment.

In the course of the study, the authors faced a lack of information on the use of agroecological practices by agricultural producers, except for organic production, which limited the assessment of the scope of agroecological initiatives in Ukraine. Further research should be directed at deepening the socio-economic aspects of the post-war reconstruction of agriculture and food supply based on agroecology, which, in particular, are related to strengthening the motivation of producers and consumers of ecologically friendly products and institutional support for their production. Additionally, a detailed analysis will be conducted on the potential economic consequences of implementing post-war agricultural recovery models.

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