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Assessment of the impact of losses of the agro-industrial complex of Ukraine due to military operations on the level of its national security (2014-2025)

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► **Abstract.** The study focused on analysing the changes in Ukraine's agricultural sector caused by the hostilities and their implications for national security, as well as finding strategies for the sector's recovery. This study employed statistical data analysis, comparative analysis, and an assessment of the impact of military operations on various aspects of the Ukrainian agricultural sector to determine the extent of damage and opportunities for recovery. The study found that Ukraine's agro-industrial complex has suffered extensive losses due to the hostilities, which posed severe risks to the country's food, economic, social, and environmental security. Specifically, the occupation and hostilities have led to the loss of some agricultural land, its mining and degradation, which has reduced the production of major crops such as wheat, maize, sunflower, barley, and in 2022, about 1.2 mil t of grain could not be stored due to damaged warehouses, and over 30% of elevators were destroyed or damaged, resulting in the loss of another 2.5 mil t of grain. soybeans. The destruction of infrastructure, blocked ports, and logistical problems caused a 60% drop in maize and wheat exports, which reduced foreign exchange earnings and commodity prices – for instance, wheat fell by 25% and maize by 30%. At the same time, massive unemployment in rural areas, a decline in livestock, and a 30% reduction in the number of farms led to an 18.4% decline in meat production and a 14.7% decline in milk production, exacerbating social problems and

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driving up prices. A labour shortage of more than 300,000 workers reduced agricultural production efficiency by 12%, and cultivated areas decreased by 10-12%. There have also been substantial environmental impacts, including soil and water pollution caused by the hostilities. To minimise these threats, comprehensive measures were needed, including mine clearance, restoration of agricultural infrastructure, diversification of logistics, and state support for agricultural producers. Implementing these measures will help stabilise the situation and ensure the country's food security. The findings can be used to develop strategies to restore Ukraine's agricultural sector, increase its resilience to crises, and strengthen national security in the face of military threats

► **Keywords:** environmental impact; infrastructure; recovery; logistics; foreign exchange earnings

► Introduction

Ukraine's agricultural sector plays a crucial role in shaping the country's economic, food, and social stability. The sector not only supplies the internal market with food, but also plays a major role in generating foreign exchange earnings through the export of agricultural products. Ukraine is one of the largest producers and exporters of grains, oilseeds, meat, and milk. The agricultural sector is also significant for the development of rural areas, which are home to a large proportion of the population working in agriculture. However, with the outbreak of the war in 2014 and the subsequent escalation of the conflict in 2022, Ukraine's agricultural sector suffered extensive losses. The occupation of territories, destruction of infrastructure, mining of agricultural land, restrictions on access to ports and transportation of products, and reduced yields due to hostilities have all led to a decline in production and exports, which has markedly affected the country's economy and national security (Diachenko & Zhmudenko, 2023). The loss of agricultural land and infrastructure has directly affected food security, as production of staple foods has decreased, and disruption of logistics routes has made it challenging to deliver products to consumers. This has caused economic hardship and social tensions in the country. The threat of food insecurity and growing social problems were consequences of the war, making the restoration of the agricultural sector crucial to national security (Shahini *et al.*, 2023).

Analysing the effects of hostilities on the agricultural sector requires examining a series of key issues, including economic, social, and environmental consequences. B.R. Rexhepi *et al.* (2023) studied the economic impact of the war on the agricultural sector, emphasising the significance of the agricultural sector for the country's economy. The destruction of this sector due to hostilities could lead to serious problems in ensuring food security and foreign exchange earnings. F. Tersoo Gbaeren *et al.* (2024) examined the social consequences of the destruction of agricultural infrastructure, especially for rural areas. The destruction of jobs and infrastructure led to mass unemployment and social instability in regions, where agriculture was the principal source of income. R.P. Tucker & J.R. McNeill (2025) analysed the environmental impact of the war on agricultural land, focusing on mining and soil contamination. This greatly complicated the restoration of agricultural production in the affected areas. C.G. Fit *et al.* (2025) addressed the technical aspects of restoring agricultural infrastructure, highlighting the need to modernise machinery and rebuild warehouses. The researchers also emphasised the significance of processing agricultural waste into value-added products for sustainable development.

R. Key *et al.* (2024) explored the effects of port blockades on agricultural exports, which limited foreign exchange earnings. The development of alternative logistics routes has become key to restoring exports and maintaining economic stability. S. Qu *et al.* (2024) investigated the impact of the war on international agricultural trade, noting that the disruption of foreign trade reduced competitiveness in world markets. M. Prem *et al.* (2025) stressed the significance of demining agricultural land for its further use. Without safe access to these lands, the resumption of agricultural production would be impossible. T.-H. Le *et al.* (2022) studied the social consequences of the war, including internal migration and increased social tensions due to job losses in agriculture. This could have led to marked social upheaval, especially in rural areas. T. Ghebreyohannes *et al.* (2022) analysed state support for the agricultural sector during the war, emphasising the need for subsidies, soft loans, and insurance to help farmers restore production capacity and maintain the stability of the sector. N. Denissova & R. Born (2021) studied the role of international aid in the post-war recovery of the agricultural sector. Attracting foreign investment and grants is crucial for rebuilding infrastructure and ensuring sustainable development of the agricultural sector. Overall, despite the existing research, the issues of adaptation of the agricultural sector to new conditions after the war, integration of international aid, and a comprehensive approach to restoring ecosystems and infrastructure are still understudied.

The purpose of the study was to assess the effects of military operations on the agricultural sector and identify effective ways to restore it to reduce the negative consequences and strengthen the country's national security. Objectives of the study were as follows: to consider the impact of the destruction of agricultural infrastructure on food security and the national economy; to assess the extent to which the decline in agricultural production affects the stability of national security; to identify the primary ways to restore the agricultural sector to reduce the adverse effects of the war.

► Materials and methods

This study analysed, how military operations affected Ukraine's agricultural sector and their implications for food security. The period from 2014 to 2025 was covered, with a focus on the destruction of infrastructure, loss of land, and decline in agricultural production. Particular consideration was given to the problem of declining yields and the difficulty of restoring the agricultural sector after the hostilities. The study also focused on the adverse economic consequences for the country arising from these

factors. One of the principal methods employed was the analysis of statistical data, which helped to track changes in the agricultural sector. The data for the analysis were taken from the Food and Agriculture Organization of the United Nations (2025) and State Statistics Service of Ukraine (2025). Geospatial analysis was employed to investigate the consequences of the occupation of territories and land contamination due to mining. This allowed assessing the extent of the loss of agricultural land that became unsuitable for cultivation after the Russia seized the territories. For this, mapping materials and satellite images from Global Forest Watch (n.d.) were used. This approach helped to analyse in detail, how the war changed the area of land available for agricultural activities, which severely affected the agricultural production.

A prominent aspect of the study was also the destruction of agricultural infrastructure, including elevators, warehouses, and processing plants. For this, the study used data on logistics failures obtained from Agricultural market research (n.d.). This analysis helped to assess, how the damage to infrastructure affected farmers' ability to store and process their produce. The study also examined, how these problems hampered access to crucial inputs, such as fertiliser and fuel, which are critical to the proper functioning of the agricultural sector. The impact of the blockade of ports on the Black Sea was analysed by studying the export and internal markets for agricultural products. The data from The National Academy of Agrarian Sciences of Ukraine (n.d.) were used to identify changes in the market situation and determine the economic consequences of the blockade of ports for the agricultural sector. The blockade has greatly complicated the export of agricultural products, leading to an oversupply of goods in the internal market and falling prices, which created financial challenges for farmers. Particular attention was paid to the livestock sector, where the war led to a major reduction in meat and dairy production. Data from the State Statistics Service of Ukraine (2025) were used to assess the extent of the decline in production. This helped to investigate, how farm damage and feed shortages affected the overall state of the industry and its ability to meet the food needs of the population.

A study was also conducted on the effects of staff shortages in the agricultural sector caused by emigration and human losses. Statistical data from the Migration research and publications (n.d.) helped to assess, how the reduction of the labour force complicated the recovery of agricultural production. The study of these factors helped to identify the key challenges faced by the agricultural sector in the context of recovery and assess their effects on the overall productivity of the sector. The study analysed the influence of military operations on Ukraine's agricultural sector and compared it with the experience of three other countries – Poland (World Bank Group in Poland, n.d.), Israel (Statistics, n.d.), and Syria (Syrian Arab Republic, n.d.). The study examined, how each of these countries managed to restore the agricultural sector after military conflicts. It was vital to identify the key factors that affect the effectiveness of restoring agricultural infrastructure and the stability of food security. These methods provided a comprehensive picture of the effects of the war on Ukraine's agricultural sector. The study of

each of the factors helped to identify key obstacles to the industry's recovery in the wake of the war, which is essential for ensuring food security and economic stability in the country in the future.

► Results

One of the most severe consequences of the war was the loss of major areas of fertile land that ended up in the temporarily occupied territories or mined. Ukraine has historically been one of the world's largest grain producers, and the reduction in cultivated areas has directly affected the yields and food security. Mine action and fighting have caused physical damage to the soil, complicating the recovery. Artillery, rocket, and armoured vehicle explosions change the chemical composition of the soil, making it less fertile. Furthermore, large areas must be demined, which is a lengthy and costly process. International organisations such as the Food and Agriculture Organization of the United Nations estimated that over 30% of Ukrainian agricultural land has become temporarily unusable, greatly reducing food production capacity (Daszkiewicz, 2022).

The destruction of key infrastructure, such as elevators, warehouses, processing plants, and logistics centres has substantially hampered agricultural production. The lack of adequate grain storage facilities resulted in crop losses, as the products often could not be stored or sold in time. The destruction of agricultural processing plants drastically affected the food industry, as a great portion of agricultural products could not be processed and sold on internal or external markets. Logistical challenges hampered the supply of fertilisers, fuel, and crop protection products, which was another factor in the decline in yields. The situation was particularly critical in 2022-2023, when many farms were unable to obtain the necessary resources for the sowing campaign due to the hostilities (Nycz-Wojtan, 2023). An analysis of the destruction of agricultural infrastructure, including elevators, warehouses, and processing plants, revealed severe consequences for Ukraine's agricultural sector. According to Agricultural market research (n.d.), over 30% of elevators were destroyed or damaged, resulting in the loss of about 2.5 mil t of grain due to the lack of adequate storage capacity. In 2022, about 1.2 mil t of grain could not be stored due to damaged warehouses, causing major losses. Infrastructure problems also led to logistical disruptions and delays in delivering products to markets, which reduced the economic performance of the agricultural sector by 7-10%. At the same time, the availability of inputs such as fertilisers and fuel decreased by 20-25%, which made agricultural operations more challenging and led to a 15-20% decline in yields. The 30-40% reduction in the production capacity of processing companies compared to pre-war levels also led to a 35% decrease in the processing of agricultural products, which adversely affected the country's economy and food security.

Before 2022, Ukraine was one of the largest grain exporters, ensuring the food security of many countries, particularly in Africa and the Middle East. However, after the outbreak of full-scale hostilities in 2022, Ukrainian ports on the Black Sea were blockaded, effectively paralysing agricultural exports. The Grain Corridor, created with the support of UN in mid-2022, enabled partial resumption

of supplies, but exports stayed well below pre-war levels (Hassen & El Bilali, 2022). As a result, Ukrainian farmers faced a surplus of products that they could not sell, which led to falling prices on the internal market and financial difficulties in the agricultural sector. The congestion of rail and road routes across the western border could not fully compensate for the loss of maritime exports, as these routes were much more expensive and less efficient. Due to the war, a considerable part of the sown area was not properly planted or cultivated. The main reasons for this include the inability to access land due to hostilities or occupation, shortages of fuel, fertilisers and crop protection products, and the destruction of irrigation systems, which is particularly critical in the southern regions. F. Lin *et al.* (2023) emphasised that in 2022-2023, Ukrainian farmers faced a lack of sufficient funding for the sowing campaign. Banks and investors were reluctant to provide loans due to high risks, which further complicated the situation. The result was a decline in the harvest of strategic crops such as wheat, maize, and sunflower. This not only reduced farmers' incomes, but also threatened food security in the country and caused food prices to rise.

The livestock sector also suffered severe losses. Due to the destruction of farms, lack of feed, and challenges in selling products, many agricultural enterprises were forced to reduce production or cease operations altogether (Laber *et al.*, 2023). The key challenges included the physical destruction of livestock farms and holdings, a shortage of feed due to reduced grain and oilseed yields, logistical problems that complicated the transportation of livestock products, and a loss of internal and external demand due to a drop in the population's purchasing power. The decrease in production of meat and dairy products resulted in higher prices, which adversely affected the living standards of the population. The war in Ukraine dramatically affected the livestock sector, which resulted in a decline in meat and dairy production. According to the State Statistics Service of Ukraine (2025), in 2022, meat production decreased by 18.4% and dairy production – by 14.7%. This was caused by damage to livestock farms,

feed shortages, and a decrease in the number of operating farms, which led to a 30% reduction in their number. As a result, the market witnessed a sharp rise in prices: meat prices increased by 22% and milk prices grew by 18%. These factors strongly affected the country's food security and increased dependence on imported supplies.

The authors A. Manaye *et al.* (2023) noted that the agricultural sector also suffered from major human losses. The war claimed the lives of many farmers, agricultural workers, and experts, exacerbating the staff shortage. Many skilled professionals were forced to leave their jobs due to mobilisation, evacuation, or the destruction of their businesses. This created further problems for the agricultural sector, as without experienced workers, the restoration of production would be significantly complicated. The situation was particularly acute in rural areas, where the loss of has led to an increase in poverty and social tensions. A study of the effects of labour shortages in the agricultural sector caused by emigration and human losses revealed considerable difficulties for the recovery of production. According to the Migration research and publications (n.d.), at the end of 2023, Ukraine's agricultural sector lacked more than 300,000 workers, which was 15% of the total workforce before the war. This resulted in a 10-12% reduction in cultivated areas, which led to an 8-10% drop in yields. The cost of agricultural operations increased by 25%, while the overall efficiency of agricultural production decreased by 12%, which complicated the sector's recovery and exacerbated the country's food security. The war substantially affected Ukraine's national security, which included not only military aspects, but also economic, social, and environmental ones. The agricultural sector, which was the backbone of the economy and provided a great part of food security, suffered severe losses. The disruption of agricultural production posed a threat not only to Ukraine, but also to its international partners. The war led to pronounced changes in the production of major crops, which threatened the food security of Ukraine and other countries that imported Ukrainian grain (Table 1).

Table 1. Dynamics of production of major crops in Ukraine (2014-2025)

Year	Wheat (mil t)	Maize (mil t)	Sunflower (mil t)	Barley (mil t)	Soybeans (mil t)
2014	24.0	28.0	12.0	8.0	3.0
2015	26.0	30.0	14.0	9.0	3.5
2016	27.0	32.0	15.0	9.5	4.0
2017	28.0	33.9	16.0	10.0	4.5
2018	29.0	35.0	17.0	10.5	5.0
2019	30.0	36.0	18.0	11.0	5.5
2020	31.0	37.0	19.0	11.5	6.0
2021	33.0	39.0	20.0	12.0	6.5
2022	19.0	22.0	10.0	5.0	2.5
2023	20.0	23.0	12.0	6.0	3.0
2024	25.0	27.0	15.0	7.0	3.5
2025	30.0	35.0	18.0	8.0	4.0

Source: based on State Statistics Service of Ukraine (2025)

In the pre-war period, agricultural production in Ukraine grew steadily, showing positive dynamics in all major crops. The highest levels were achieved just before the outbreak of full-scale war. After 2022, production

declined sharply due to the loss of territory, infrastructure destruction, and logistical difficulties. However, in the following years, a gradual recovery in volumes was observed, which demonstrated the high resilience and

adaptability of the agricultural sector. It was expected that in the short term, production levels would again approach pre-war levels. The loss of areas, where wheat, barley, and soybeans were historically grown, including areas in the east and south of the country, led to a decline in the area under cultivation. This meant not only a reduction in the amount of milling wheat on the internal market, but also major challenges in meeting export obligations, as Ukraine was historically one of the largest exporters of wheat on the global market. As of 31

December 2023, significant areas in the east and south of Ukraine, including parts of Donetsk, Luhansk, Zaporizhzhia, and Kherson regions, continued to be temporarily occupied. These regions are crucial for the country's agricultural sector, as they are home to fertile soils, large agricultural enterprises, and infrastructure facilities. The occupation complicated access to resources, disrupted logistics chains, reduced yields, and limited control over agricultural potential. The loss of these territories drastically affected Ukraine's economy and food security (Fig. 1).

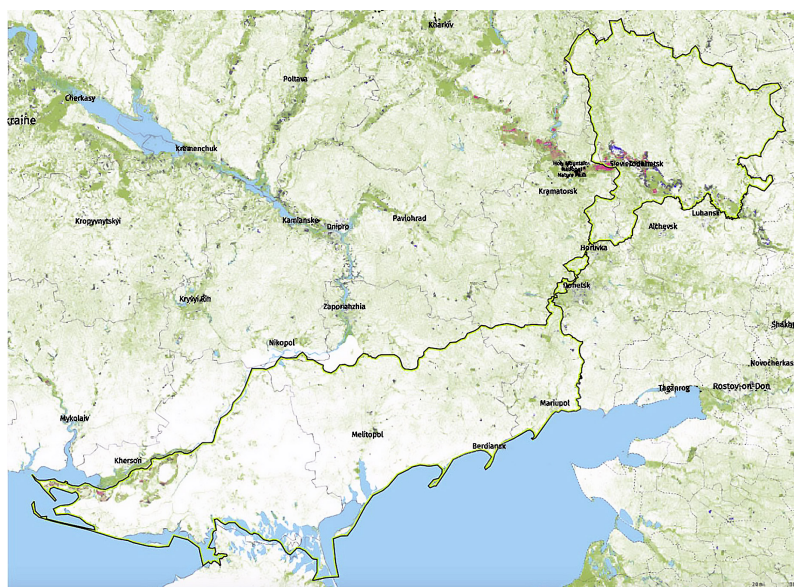


Figure 1. Temporarily occupied territories after the full-scale invasion

Note: the boundary of the territories is defined as of 31 December 2023

Source: based on Global Forest Watch (n.d.)

Barley, which is one of the main export crops, also suffered considerable losses. Many regions that historically grew barley were under occupation or in the zone of active hostilities, which significantly reduced the area under this crop. The lack of infrastructure for barley harvesting and transportation further complicated the situation, resulting in a decrease in the amount of barley available on the internal market and for export. The production of soybeans, which is a valuable crop for providing protein for both the internal market and exports, also experienced major challenges. Specifically, the decline in soybean acreage caused by the lack of access to certain areas and restrictions on the supply of inputs such as fertilisers and crop protection products led to a decline in production of this crucial crop for the agricultural sector. Maize production suffered extensive losses due to shortages of fertilisers, fuel, and crop protection products. Lack of access to the necessary resources for efficient cultivation of this crop made it almost impossible to grow it in some areas. Additionally, the lack

of access to warehouses and logistics networks for storing and transporting maize was yet another obstacle. The decline in the area under oilseeds such as sunflower, as well as the decline in barley and soybean plantings, was the result of the Russian aggression. Oilseeds and pulses require stable conditions for transportation through ports, which Ukraine lost due to the blockade and destruction of port infrastructure. This drastically limited export opportunities and created a shortage of oilseeds and protein crops in the country. The outcome was not only in food shortages on the internal market, but also in instability on international markets, where Ukrainian grain had always played a prominent role in ensuring food security, particularly for countries in Africa and the Middle East. K. Mazur & O. Aliksieieva (2024) noted that, before the war, the agricultural sector was one of the key sources of foreign exchange earnings in Ukraine, accounting for about 40% of foreign exchange earnings. Losses in the agricultural sector were a serious blow to the country's economic stability (Table 2).

Table 2. Effects of the war on the economic performance of Ukraine's agricultural sector

Year	Gross agricultural production (bn USD)	Exports of agricultural products (bn USD)	Investments in the agricultural sector (bn USD)	Number of agricultural enterprises	Employment in the agricultural sector (mil people)
2014	50.0	20.0	1.5	25,000	3.0
2015	52.0	22.0	1.8	24,500	2.9
2016	53.0	23.0	2.0	24,000	2.8

Table 2, Continued

Year	Gross agricultural production (bn USD)	Exports of agricultural products (bn USD)	Investments in the agricultural sector (bn USD)	Number of agricultural enterprises	Employment in the agricultural sector (mil people)
2017	54.0	24.0	2.2	23,500	2.7
2018	55.0	25.0	2.5	23,000	2.6
2019	56.0	26.0	2.8	22,500	2.5
2020	57.0	27.0	3.0	22,000	2.5
2021	58.0	28.0	3.2	21,500	2.4
2022	30.0	12.0	0.5	18,000	2.0
2023	32.0	15.0	1.0	19,000	2.1
2024	35.0	18.0	1.5	20,000	2.2
2025	40.0	22.0	2.0	21,000	2.3

Source: based on Food and Agriculture Organization of the United Nations (2025)

Prior to the outbreak of full-scale war, Ukraine's agricultural sector was showing steady growth, with increasing production, exports, and investment, although the number of agricultural enterprises and employment were gradually declining. In 2022, the sector experienced a sharp decline in all indicators due to the war. At the same time, a gradual recovery was being observed since 2023: exports, investments, the number of enterprises, and employment were growing, suggesting the beginning of the industry's recovery. The blockade of ports, particularly those in the Black Sea, and the destruction of logistics chains substantially limited agricultural exports. Ukraine lost access to major markets for its products, including Europe, Africa, and the Middle East. The decline in agricultural exports meant not only a decrease in farmers' incomes, but also major losses for the budget, as most of the country's foreign exchange earnings were generated by agricultural exports. Agricultural enterprises responsible for processing products, including elevators, grain processing plants, and other storage and logistics facilities, were destroyed or severely damaged. This not only complicated the processing of the harvest, but also put millions of people out of work, further deepening the economic crisis. Agricultural enterprises faced a major funding shortage due to high investment risks. Banks and other financial institutions reduced lending, making it impossible for the sector to recover and modernise. Without government and international support, farmers could not return to pre-war production levels. The loss of foreign exchange earnings, declining tax revenues, and a substantial budget deficit exacerbated economic challenges and increased dependence on international aid.

An analysis of the effects of the blockade of ports on the Black Sea, based on data from The National Academy of Agrarian Sciences of Ukraine (n.d.), found a significant negative impact on agricultural exports. After the blockade of ports in 2022, wheat and maize exports decreased by 60%, leading to a surplus of products on the internal market. This led to a 25% drop in wheat prices, a 30% drop in maize prices, and a 20% drop in sunflower prices. Farmers faced financial difficulties as they were unable to sell their products at favourable prices, which reduced their income by 15-20% and adversely affected the level of investment in agriculture, ultimately reducing production by 10-15% in 2023. The destruction of agricultural infrastructure and reduced agricultural production not only affected the economy, but also had major social consequences (Moersdorf et

al., 2023). Agriculture was the principal source of income for millions of people, especially in rural areas. The loss of jobs on farms, in processing plants, and in logistics companies led to a sharp increase in unemployment. The lack of alternative employment opportunities made many rural communities socially unstable. As living conditions in rural areas deteriorated, many people began to move to cities or abroad in search of better living conditions. This migration put more strain on urban infrastructure, contributing to social tensions and increasing competition for resources in cities. Cancellation of social programmes, lower living standards, and an unstable labour market could lead to severe social conflicts. Internal tensions in rural communities could escalate into mass protests and unrest.

The environmental consequences of the war may have long-lasting effects on the environment, making it difficult to restore the agricultural sector at all levels (Meaza et al., 2024). Large areas that were previously used for agricultural work have become unsafe due to mines. This made them unsuitable for cultivation and made it impossible for agricultural enterprises to function normally, leading to losses not only in agricultural work, but also in land contamination. The destruction of irrigation infrastructure, as well as the destruction of water systems that provided water to farms, led to drought and reduced yields in the southern and eastern regions. This has severe consequences not only for agriculture, but also for the overall state of water resources. The use of chemical warfare agents and leaks of oil products and chemicals during shelling led to severe contamination of soil and water resources (Shaforost et al., 2024). This created long-term problems for agriculture, as the contamination of the soil made it unsuitable for growing crops. Fires caused by shelling were destroying forests and nature reserves, which was damaging biodiversity. The war negatively affected local ecosystems, increasing the risks to the natural balance.

The war that broke out in Ukraine in 2014 posed a serious challenge to the country's agricultural sector. Destroyed infrastructure, loss of land, reduced yields, and labour shortages are just some of the problems that have arisen as a result of the hostilities. Ukraine, with one of the largest agricultural productions in Europe, needed effective measures to restore its agricultural sector. To assess this situation, it is useful to consider the experience of other countries that experienced analogous crises, such as Poland, Israel, and Syria. Poland, which also suffered severe destruction during World War II, managed to quickly

rebuild its agricultural sector thanks to effective government programmes and international financial support. Specifically, the Polish government developed strategies that included providing subsidies to farmers, financing infrastructure rehabilitation, and introducing the latest agricultural technologies. This allowed Poland not only to restore agricultural production, but also to become one of the largest agricultural countries in Europe, which played a significant role in the continent's food security (World Bank Group in Poland, n.d.).

Israel, for its part, faced other challenges caused by the constant threat from its neighbours, but the country managed to find effective solutions through innovative technologies. Israel was actively using hydroponics, drip irrigation, and automation of agricultural processes, which helped it to make the most efficient use of limited water and land resources. A prominent aspect was also the availability of an efficient infrastructure for storage and processing of products, which had become the key to the sustainability of the agricultural sector even in challenging conditions (Statistics, n.d.). The Syrian experience, while less successful, also provided valuable lessons. Syria suffered heavy losses in the agricultural sector during the war, including the destruction of large tracts of farmland and a decline in production of major crops. In response to these challenges, the government has sought international aid to rebuild infrastructure and support farmers. However, due to the lack of stability and ongoing hostilities, recovery was greatly slowed. This experience underscored the significance of stable security for the effective recovery of the agricultural sector (Syrian Arab Republic, n.d.).

Comparing these examples with the situation in Ukraine, several key aspects can be identified. Ukraine, on the one hand, has a strong agricultural infrastructure and significant potential for recovery, but due to the armed conflict and the loss of territory, the country faces challenges in obtaining financing and restoring production capacity. However, thanks to international support and the restoration of some infrastructure, Ukraine's agricultural sector was gradually beginning to recover. Another prominent area was the development of innovative technologies in agriculture, which enabled the optimised use of limited resources. The experience of Poland and Israel was most relevant for Ukraine, as these countries, like Ukraine, have a strong agricultural sector and have faced the challenges of recovering from large-scale conflicts. Specifically, Poland, with its financial instruments to support farmers, and Israel, with its innovative solutions, can serve as examples for Ukraine in the conflict.

Restoring Ukraine's agricultural sector required a comprehensive approach, including both international financial support and the introduction of modern technologies that can ensure the efficiency of agricultural production even in the face of armed conflict. Despite the large-scale losses, Ukraine's agricultural sector has great potential for recovery, which could become the basis for stabilising the economy and maintaining food security. One of the first steps to restore the agricultural sector was to clear mines, especially in Eastern and Southern Ukraine, where large areas of agricultural land were mined due to the hostilities. This will not only allow the land to be returned to agricultural use, but will also help to avoid further human casualties.

For this, Ukraine can engage international support programmes and humanitarian demining, which will enable a faster start to the resumption of agricultural activities in the hazardous areas. The damaged agricultural infrastructure, including elevators, warehouses, ports and transport routes, must be modernised. Rebuilding these facilities will ensure uninterrupted storage, transportation, and processing of agricultural products, which was critical to restoring production capacity. Prominent aspects included the modernisation of port facilities on the Black and Azov Seas, as well as the development of alternative logistics routes through the Danube ports and railway routes.

An essential element of the agricultural sector's recovery is to support agricultural producers through government lending and compensation programmes. This will allow farmers to resume operations after significant losses incurred as a result of the war. Furthermore, it is necessary to create conditions to ensure access to resources for the resumption of production, including compensation for the cost of agricultural machinery, fertilisers, and plant protection products. The use of the latest technologies is key to increasing the efficiency of agricultural production. The recovery of the agricultural sector should include the introduction of innovative technologies, such as drones for crop monitoring, satellite monitoring of land, and the development of climate-resilient crop varieties. Digitalisation of processes, automation of farm management, and cost optimisation will help to markedly increase productivity and reduce costs.

Considering the destruction of conventional logistics routes, it is vital to develop alternative ways to export agricultural products. The reopening of the Danube ports, railway routes, and road transport infrastructure will help to increase export volumes even under limited conditions. Furthermore, diversification of agricultural exports will reduce dependence on a single market and minimise risks in case of shifts in demand or problems in certain markets. Restoration of Ukraine's agricultural sector is an arduous, but achievable task that requires a comprehensive approach, including land demining, infrastructure modernisation, support for producers and the introduction of the latest technologies. This will not only restore agricultural production, but also strengthen the country's economy, return the country to stable production and exports, and ensure food security.

► Discussion

The study found that the war caused extensive losses to Ukraine's agricultural sector, which substantially affected the country's national security. First of all, a significant part of agricultural land, particularly in the east and south of the country, was in the combat zone or temporarily occupied, which led to a decrease in production capacity. This directly affected the country's food security, as significant amounts of land historically used for growing staple crops became unusable for cultivation. Furthermore, the shortage of agricultural inputs such as fertilisers, pesticides, and machinery markedly reduced yields in the rest of the territory.

Y. Zhou *et al.* (2021) also investigated this problem, where the findings confirmed that the loss of agricultural land can severely affect national security, as the reduction

of the area for growing crops directly threatens the stability of the country's food system. Reduced food production due to lost land can lead to food shortages, creating conditions for economic and social tensions. In the context of globalisation and population growth, these consequences can have not only national, but also regional and international implications. M. Kuiper & H.D. Cui (2021) also showed that the loss of land suitable for agriculture can seriously affect food security, as the ability to meet the food needs of the population becomes more vulnerable. Reducing the amount of land available for cultivation reduces a country's ability to ensure its own food supply, leading to dependence on imports and market instability. This can increase social tensions and contribute to rising prices for staple foods. Notably, the loss of agricultural land can be the outcome of both natural and anthropogenic factors. Soil contamination, erosion, urbanisation, and industrialisation all lead to a reduction in the area of fertile land (Melnychenko, 2024). At the same time, climate change is a critical factor, which exacerbates negative trends in agriculture, reducing yields and increasing the frequency of natural disasters such as droughts and floods.

Ukraine's agricultural infrastructure also suffered severe damage due to the hostilities. Damage to warehouses, elevators, storage systems, and transport networks substantially hampered the storage and transportation of agricultural products. This affected the ability of the agricultural sector to supply the internal market and perform export obligations, which negatively influenced the country's economic security (Pylypenko *et al.*, 2025). The loss of ports and blocked trade routes reduced exports, which limited foreign exchange earnings and worsened Ukraine's economic situation. M. Junaid & A. Gokce (2024) concluded that the destruction of agricultural infrastructure causes major economic losses, as the process of production and supply of agricultural products becomes disrupted. Destroyed transport networks, warehouses, and storage of machinery complicate not only production, but also sales of products, which can lead to a drop in trade. This adversely affects the country's economic growth, as agriculture is a vital component of its economy. R. Osei-Kyei *et al.* (2021) found that damage to agricultural infrastructure also seriously affects the economic security, as the country loses its ability to quickly restore production and increase exports. The destruction of the storage and processing system leads to the loss of significant economic resources, as well as social instability due to lower incomes of farmers and workers. As a result, the country becomes more vulnerable to external economic threats and loss of its economic independence. These findings confirmed the results of the above-presented study, as they demonstrated a direct link between the destruction of agricultural infrastructure and a decrease in the economic stability of a country. Admittedly, the loss of key infrastructure elements, such as transport routes and processing facilities, drastically slows down economic recovery and can lead to food shortages. Restoration of such infrastructure requires extensive financial outlays, which could delay the full economic recovery for a long time.

Declining yields due to resource constraints and challenges in securing the necessary agricultural inputs also became a key issue. As Ukraine was a major exporter of

grain and oilseeds, the decline in yields had far-reaching implications for international trade (Khodakivska *et al.*, 2023). The lack of sufficient exports created instability on international markets, where Ukrainian grain historically played a prominent role, particularly for developing countries. The decline in production has undoubtedly affected the food security of not only Ukraine, but also many other countries that were dependent on imports of Ukrainian agricultural products. A.M.D. Ortiz *et al.* (2021) also found that a decline in yields can greatly reduce a country's export potential, as reduced production volumes limit the ability to supply products to international markets. This leads to the country losing its competitive advantage in the foreign market and may also force it to import goods that it used to produce independently. In case of a steady decline in yields, the country's economy becomes vulnerable to fluctuations in global agricultural markets. O.O. Aluko *et al.* (2021) concluded that yield problems also severely affect export capacity, as lower production volumes force governments to reconsider their foreign trade strategies. Countries suffering from crop failures may be forced to limit their exports to meet internal demand, in turn leads to higher prices and shortages on global markets. This not only undermined economic stability, but can also lead to political and social conflicts over food shortages. These findings were consistent with the arguments presented in the previous section, as they confirmed the existing link between declining yields and the impact on export capacity. As noted earlier, a decline in agricultural output directly limits a country's ability to take part in international trade, making it more dependent on imports. Furthermore, these findings also confirmed the need for effective strategies to improve yields and ensure stability in export markets.

The war also led to major problems in the livestock sector, as reduced feed production, loss of feed bases, and a reduced labour force markedly reduced the production of meat, milk, and other livestock products. This was another reason for the reduction in food supply in the country, which exacerbated the food situation and led to food price inflation. The decline in livestock production not only made it more difficult to meet internal needs, but also affected Ukraine's export opportunities. L. Pinotti *et al.* (2021) confirmed that the loss of feed resources significantly affects livestock production, as a decrease in the available feed leads to a decrease in livestock production. The lack of feed resources leads to a decrease in livestock productivity, which limits the supply of meat, milk, and other livestock products to the market. This puts further pressure on the country's food security, particularly through higher prices and a growing shortage of domestic products. J. Schillings *et al.* (2021) also found that challenges in livestock production have a long-term impact on the food situation, as a decline in livestock production threatens not only the country's food independence, but also its economic stability. A decline in milk and meat production may lead to the need to import these products, increasing dependence on external suppliers. Furthermore, this could adversely affect farmers' incomes and contribute to social tensions in rural areas. Comparing the reviewed data with the findings obtained during this study, it can be

concluded that the loss of feed bases directly affected the decline in livestock production, which contributed to the aggravation of the food situation. Reduced feed availability not only reduced livestock productivity, but also made it more complicated for livestock farms that already suffered losses to recover. Thus, these findings highlighted the value of stable feed resources for food security and economic stability.

Human losses among agricultural workers were another major consequence of the war. Most agricultural workers were forced to leave their homes due to the hostilities, which led to a shortage of labour at many enterprises. The lack of skilled personnel and losses among workers complicated production processes and the resumption of agricultural activities. This also greatly affected the national security, as the decline in production capacity in the agricultural sector created more risks to the food situation in the country. A. Mishra *et al.* (2021) concluded that human losses and labour shortages in the agricultural sector have severe implications for the recovery of the agricultural sector. The decline in the number of workers, especially in the context of post-war recovery, complicated agricultural production processes, which can lead to delays in seasonal work. The lack of skilled workers and high labour out-migration, especially from rural areas, threatens the efficiency of the agricultural economy and its ability to recover from crisis periods. A.C. Newton *et al.* (2021) found that the recovery of the agricultural sector after large losses of human resources required extensive investments in education and training of new employees, as well as in creating favourable conditions for attracting labour to agriculture. Additionally, it is essential to introduce modern technologies and automation, which can compensate for labour shortages and increase production efficiency. Only a comprehensive approach to addressing the labour shortage problem can ensure a stable recovery of the agricultural sector and its sustainable development in the future.

When analysing the results, it was clear that the shortage of labour in the agricultural sector is one of the primary obstacles to the rapid recovery of the agricultural sector. The lack of skilled workers in agriculture leads to major losses in production and reduced efficiency of farms. This underscores the relevance of not only rebuilding infrastructure but also investing in human capital to ensure the sustainability of the agricultural economy in the long term. The consequences for Ukraine's national security became complex and multidimensional. The loss of agricultural land, the destruction of infrastructure, reduced exports, lower yields, and losses in livestock production became serious challenges to the country's national security in economic, food, and social terms. Restoration of the agricultural sector requires valiant efforts and resources, including investments in infrastructure rehabilitation, introduction of the latest agricultural technologies and support for farmers. Thus, the post-war recovery of the agricultural sector will be crucial for the stability of Ukraine's national security in the future.

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► Conclusions

The war severely affected Ukraine's agricultural sector, which suffered large-scale losses ranging from land loss to infrastructure destruction. Declining yields, production of major crops, and falling exports threatened food and economic security. By 2022, the agro-industrial complex accounted for up to 40% of the country's foreign exchange earnings, but due to the occupation, mining, and destruction of farmland, the area under crops shrunk drastically. This led to a drop in wheat, maize, and sunflower production, which adversely affected the internal market and exports. The blockade of ports and disruption of logistics reduced foreign exchange earnings, exacerbating the financial situation, while elevators and processing plants were destroyed, making it impossible to process and store products properly. Unemployment, internal migration, and social instability increased in rural areas due to the destruction of infrastructure and job losses. Still, Ukraine can recover – it needs landmine clearance, infrastructure upgrades, international aid, and investment in innovation. Advances in technology, digitalisation, new crop varieties, and logistics routes can greatly strengthen the agricultural sector. Support for farmers, affordable credit, and compensation for losses were key to stabilisation. The development of Danube ports and rail exports will help overcome logistical difficulties. Implementation of these steps will not only restore the agricultural sector, but also strengthen national security by ensuring Ukraine's strong position in the global agricultural market.

The study analysed, how the hostilities affected Ukraine's agricultural sector, particularly through the loss of land, destruction of infrastructure, and a decline in exports. Comparison with the experience of Poland, Israel, and Syria helped to identify effective strategies for restoring the agricultural sector in times of conflict. The findings underlined the need for a comprehensive approach to the recovery of Ukraine's agro-industrial complex, with a focus on international support, innovation, and security stabilisation. A limitation of the study was the limited amount of available data on the exact economic losses and prospects for the recovery of the agricultural sector due to the confidentiality of some information and the lack of official reports for the current period. For a more comprehensive understanding of the influence of hostilities on Ukraine's agricultural sector, it is necessary to investigate the long-term environmental consequences of the destruction of agricultural infrastructure and mining of lands.

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► **Анотація.** Дослідження було зосереджено на аналізі змін у сільськогосподарському секторі України, спричинених бойовими діями, та їх наслідках для національної безпеки, а також на пошуку стратегій відновлення сектору. У цьому дослідженні використовувався статистичний аналіз даних, порівняльний аналіз та оцінка впливу військових операцій на різні аспекти сільськогосподарського сектору України, щоб визначити масштаби збитків та можливості для відновлення. Дослідження показало, що агропромисловий комплекс України зазнав значних втрат через бойові дії, що створює серйозні ризики для продовольчої, економічної, соціальної та екологічної безпеки країни. Зокрема, окупація та бойові дії призвели до втрати деяких сільськогосподарських культур, таких як пшениця, кукурудза, соняшник, ячмінь, а у 2022 році близько 1,2 млн тонн зерна не могло зберігатися через пошкоджені склади, понад 30 % елеваторів було знищено або пошкоджено, що призвело до втрати ще 2,5 млн тонн зерна та сої. Руйнування інфраструктури, блокування портів та логістичні проблеми спричинили падіння експорту кукурудзи та пшениці на 60 %, що зменшило надходження іноземної валюти та ціни на сировинні товари – ціни на пшеницю впали на 25 %, а на кукурудзу – на 30 %. Водночас масове безробіття в сільській місцевості, скорочення поголів'я худоби та скорочення кількості фермерських господарств на 30 % призвели до зниження виробництва м'яса на 18,4 % та молока на 14,7 %, що загострило соціальні проблеми та призвело до зростання цін. Дефіцит робочої сили, понад 300 000 працівників, знизив ефективність сільськогосподарського виробництва на 12 %, а посівні площі скоротилися на 10-12 %. Також спостерігався значний вплив на навколишнє середовище, включаючи забруднення ґрунту та води, спричинене бойовими діями. Для мінімізації цих загроз необхідні комплексні заходи, включаючи розмінування, відновлення сільськогосподарської інфраструктури, диверсифікацію логістики та державну підтримку сільськогосподарських виробників. Впровадження цих заходів допоможе стабілізувати ситуацію та забезпечити продовольчу безпеку країни. Результати дослідження можуть бути використані для розробки стратегій відновлення сільськогосподарського сектору України, підвищення його стійкості до криз та зміцнення національної безпеки перед обличчям військових загроз

► **Ключові слова:** вплив на навколишнє середовище; інфраструктура; відновлення; логістика; надходження іноземної валюти