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International Yearbook of Soil Law and Policy 2025

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The *International Yearbook of Soil Law and Policy* is a book series that discusses the central questions of law and policy with regard to the protection and sustainable management of soil and land. The Yearbook series analyzes developments in international law and new approaches at the regional level as well as in a wide range of national jurisdictions. In addition, it addresses cross-disciplinary issues concerning the protection and sustainable management of soil, including tenure rights, compliance, food security, human rights, poverty eradication and migration. Each volume contains articles and studies based on specific overarching topics and combines perspectives from both lawyers and natural scientists to ensure an interdisciplinary discourse.

The *International Yearbook of Soil Law and Policy* offers a valuable resource for lawyers, legislators, scholars and policymakers dealing with soil and land issues from a regulatory perspective. Further, it provides an essential platform for the discussion of new conceptual approaches at the international, national and regional level.

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Foreword

Greeting for Volume 7, IYSLP

When the first volume of the *International Yearbook of Soil Law and Policy* was published in 2016, the general mind-set was very different than today: Humanity was facing fundamental challenges, such as climate change, hunger and poverty, geopolitical conflicts, but there was a prevailing belief that transformative mechanisms for greater sustainability are available and could be developed and implemented. Societies and political leaders were hopeful that the world could be changed for the better. The sustainability agenda adopted by the UN General Assembly September 2015 provided both the trajectories to be followed and a roadmap for the measures and mechanisms to be put in place.

About 10 years later, the "world" has changed dramatically. Since 2015, humanity has been confronted with a series of global crisis. To name just a few: the migration crisis particularly in Europe in 2015, the Covid-19 pandemic from 2020 to 2022, the war against Ukraine and further military conflicts all over the globe, food and nutrition insecurity, advancing climate change and increasingly severe extreme weather events, the biodiversity and pollution crisis, the increasing loss of confidence in democratic and rule of law-based political systems, persistent racist concepts, multilateralism weakened inter alia by the Trump administration and the risk of a new level of antagonistic geopolitical strategies.

Thus, the complexity of the political challenges has increased significantly, as all these crises are interlinked at least to some extent. Silo approaches are therefore generally, insufficiently complex and tend to fail.

Soil and land are severely affected by the multiple crisis. To name just a few references: Migration could be caused by the lack of resilience of small-scale farmers to the new characteristics of extreme weather events. Migration itself could lead to new forms of soil-degrading practices. The pandemic has led to additional pollution to terrestrial areas. Cooperation aid projects have been postponed or even terminated. The conflicts in Gaza and Ukraine, for example, have devastating effects on the soils. Weakened multilateralism is undermining concepts for cooperative solutions. New tariffs could increase the costs for seeds, fertilizers and pesticides,

which could even lead to greater food insecurity, in particular for countries in the Global South.

Sustainable soil management requires strategies which take into account the three dimensions of sustainability: first ecologically sound in long terms, meaning the ecological qualities of soils are at least maintained and at best enhanced, second being socially just to ensure an adequate level of justice and equality within societies, between races, between genders, and between North and South, and thirdly to be economically reasonable which requires an adequate standard of living for all. A governance strategy which ensures that all three dimensions are met is a reasonable approach to deal with most of the crisis mentioned above. In this sense, sustainable soil management contributes inter alia to counteracting climate change, supporting climate adaptation particularly in urban areas, ensuring a permanent host for biodiversity, and counteracting the causes of migration.

Therefore, the degree to which the protection and sustainable management of soil is implemented could also be seen as an indicator of how humanity has been able to deal with the multiple crisis mentioned above and vice versa.

Volume 7 of the *International Yearbook of Soil Law and Policy* addresses the interface between the global crisis and sustainable soil management. The multidimensional interface between these multiple crises is analysed, thereby providing a valuable source of information for future academic discussions, but especially for policymakers responsible for taking all perspectives into account. Therefore, I would like to commend the editors of Volume 7 of the *International Yearbook of Soil Law and Policy* for their far-sighted concept for this volume which first provided a very insightful analysis and second is of great importance for the development of appropriate solutions. These solutions based on a comprehensive analysis and on integrative governance concepts must be implemented to ensure sustainable management of soils in order to also overcome the multiple crisis.

German Environment Agency Dirk Messner
Dessau-Roßlau, Germany

Preface

Volume 7 of the *International Yearbook of Soil Law and Policy* endeavours to address the on-going global crises in the context, and from the perspective, of sustainable soil management. In our view, this is a timely and necessary undertaking, as global tensions and challenges have dramatically increased, significantly affecting our soils.

Just to name a few of these on-going multiple crises: the geopolitical instabilities, the military conflicts—particularly in Ukraine and Gaza, the weakened multilateralism, the impact of the Covid-19-pandemic, hunger, and poverty, digitalization including artificial intelligence, and, beyond that, the three global ecological crises: climate change, biodiversity loss, and ubiquitous pollution, especially with hazardous chemicals and (micro-) plastics.

In Part I of this volume of the *International Yearbook of Soil Law and Policy* the first eleven chapters analyse the intersections of sustainable soil management with multiple global crises, such as military conflicts, migration, hunger, global health crises, digitalization, and energy transformation. The perspective is always twofold: First, the chapters analyse the impact of the individual crises on soils; and second, they explore how sustainable soil management can contribute to solve these crises.

We are of the view that the concept of analysing the global multiple crisis from the perspective of one sectoral challenge—in this case, sustainable soil management—is a very appropriate and useful one. It allows an in-depth investigation and understanding of the interfaces of the individual crises and soil management as well as the consideration of concrete options to solve or at least reduce the negative effects of the named crisis. In that sense, this concept could also be understood as a methodological blueprint for other sectors, such as water management, air pollution, or nature conservation, to better understand the effects of the many global crises.

Part II of this volume comprises four chapters on recent developments at international level. The first chapter provides an overview on how the three "Rio – conventions"—UNCCD, CBD, and UNFCCC—have integrated soil issues so far. The latter three chapters examine the last UNCCD COP, the negotiations on a global plastic treaty and on the Alpine convention.

Part III of this IYSLP comprises five chapters on national or regional development. All former volumes of the "International Yearbook of Soil Law and Policy" included this element. Part III intends to provide insights on the national and regional challenges, circumstances, and approaches in order to learn from each other and to better understand the commonalities and differences in the various regions. Reports on Austria, the European Union, Australia, Iran, and Japan are included.

Finally, Part IV includes chapters of a cross-cutting nature: two chapters on land take and soil sealing and one chapter on regulatory concepts for soils in forests in Germany are included.

Volume 7 of "International Yearbook of Soil Law and Policy" lives up to its claim of being globally oriented. Both editors and authors represent many different regions across the globe.

We would like to thank full-heartedly all authors for their insightful contributions. A special thanks goes to Dr. Laura Hofmann of Springer Publishing House, who has pushed and supported our work throughout the process and has always been a very reliable partner.

We hope that this volume will further advance discussions and contribute to networks on the topic of healthy soils and sustainable soil management and will also contribute to finding concrete solutions, especially to overcome the global multiple crises.

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Contents

Cross-cutting Issues

Soil, War, and the Battle Against Misinformation: Debunking Myths in Ukraine's Agricultural Recovery

Olena Melnyk, Maksym Solokha, Patrick Waeber, David O'Connor, Mykola Bykov, Mariia Storchak, Oksana Datsko, and Elina Zakharchenko

Abstract The war in Ukraine has caused severe socio-economic and environmental damage, significantly impacting the country's agricultural sector. Ukraine, once a major global food supplier, faces challenges such as soil contamination, land degradation, and disrupted supply chains due to military activities. Additionally, misinformation and disinformation campaigns threaten to distort perceptions of Ukraine's agricultural viability, undermining recovery efforts. This chapter critically examines the environmental impact of the war on Ukraine's soils and agriculture while

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debunking key myths surrounding its recovery. By analyzing scientific data, policy measures, and international collaboration, the study highlights Ukraine's resilience and the steps necessary for sustainable agricultural restoration.

1 Introduction

In February 2022, Russia launched a full-scale war against Ukraine, causing deep socio-economic and environmental upheaval.[1,2] The conflict has caused more than €49.4 billion (USD) in environmental damage, including widespread chemical contamination of air, water, and soil.[3] Even before the war, Ukraine faced significant environmental challenges like soil erosion,[4] air pollution,[5] drought, and extreme heatwaves,[6] with the war further intensifying these issues.

Before the war, Ukraine's agriculture sector provided employment for 14% of the population, contributed 12% of its GDP (rising to 20% with the rest of the food industry included), and accounted for 41% of total exports.[7] As one of the world's largest grain exporters, Ukraine supplied food to approximately 400 million people globally, making it a critical player in global food security.[8] However, war-related disruptions have severely affected its agricultural production. Soil contamination from military activities has degraded farmland potential, and the destruction of irrigation systems has further reduced productivity. Port blockades have restricted exports, while widespread minefields have made large areas of agricultural land inaccessible for cultivation. An estimated 18–20% of its cropland is left unplanted, and total agricultural losses, including increased production costs and lost revenues, amount to €32 billion (Euro).[9]

According to the Ministry of Defense of Ukraine, since the onset of the invasion, Russia has launched over 15,000 drones, 10,000 missiles, and 40 million artillery shells, a substantial portion of which will have affected the soil environment.[10,11] This significantly complicates the future use of the lands for agricultural production. An additional threat arises from the widespread mining of territories. Ukraine

[1] Pereira et al. (2022).
[2] Melnyk and Koulabdara (2025).
[3] Hryhorczuk et al. (2024).
[4] Tarariko et al. (2021).
[5] Shelestov et al. (2021).
[6] UN Ukraine (2021).
[7] Melnyk and Koulabdara (2025).
[8] FAO (2023).
[9] Kulish (2022).
[10] Defense Express (2025).
[11] Wikipedia Contributors (2025a).

has become the most mined country in the world, surpassing Syria and Afghanistan,[12] with approximately 139,000 km^2 of land requiring demining, which poses a serious challenge to the recovery of the agricultural sector.[13]

While the environmental impacts of war are not unique to Ukraine, with serious land degradation issues observed in the twentieth and twenty-first century battlefields,[14] the consequences of modern warfare are less well-known than the impact of past conflicts. Military activity has evolved, and the consequences of modern warfare have not been studied as thoroughly. The bombardment of Ukraine's highly fertile soils (chernozems) is also unprecedented. These soils have played a key role in the development of its agricultural sector, serving as the foundation for the country's food security and economic stability.

While these challenges are real, another serious threat has emerged—misinformation. Alongside the direct impacts of war, Ukraine is at the center of an information war that seeks to undermine its sovereignty and economic resilience. Disinformation campaigns spread false or exaggerated claims about soil contamination, agricultural collapse, and the long-term viability of Ukraine as a global food producer.[15] This creates economic and political risks by discouraging investment, disrupting trade, and fostering uncertainty about Ukraine's recovery.[16]

This chapter goes beyond assessing damage to Ukraine's soils and agriculture. It examines how misinformation and disinformation shape international perceptions and decision-making. Misinformation refers to false or misleading information spread without intent to deceive. Disinformation is deliberately crafted to mislead. Both distort reality. This chapter identifies and debunks three major myths about Ukraine's agricultural situation: (i) the myth that Ukraine lacks mechanisms to assess soil damage and compensate for environmental losses, (ii) the myth that a significant portion of arable land has become unusable due to contamination or radioactive exposure, and (iii) the myth that Ukraine's agricultural sector is in irreversible decline and will take decades to recover.

By addressing these myths and contrasting them with scientific evidence and policy realities, we demonstrate that Ukraine's agricultural resilience is stronger than often portrayed. The findings highlight the need for data-driven assessments, clear communication strategies, and international cooperation to counteract misinformation and support Ukraine's recovery.

[12] Novin (2023).

[13] Bayda (2025).

[14] Van Meirvenne et al. (2008), Nessy (2017), National Geographic Society (2023), Parliamentary Assembly of the Council of Europe (2001).

[15] Dubóczi and Škríbová (2023).

[16] Nofenko (2019); Kuzepal (2023).

2 Disinformation vs. Facts: An Overview of Ukraine's Agricultural Resilience After Three Years of War

War does not just destroy landscapes, infrastructure, and lives. It also shapes narratives. In Ukraine, physical devastation is only part of the story. An information war distorts perceptions of the country's agricultural resilience. Misinformation and disinformation fuel three major myths about the state of Ukraine's soils and agriculture. These narratives come from foreign propaganda, misinterpreted data, and political agendas. They influence international decision-making, trade relations, and post-war recovery efforts. This section examines these myths and contrasts them with evidence-based assessments to provide a clearer picture of Ukraine's agricultural future.

Among the targeted information manipulations, several main strategies can be identified. The first is undermining Ukraine's reputation as an agricultural exporter by spreading unsubstantiated claims about critical contamination of soils with contaminants such as heavy metals and radionuclides, and insufficient state control, allegedly threatening the quality of agricultural products. The second is creating obstacles to the supply of weapons to Ukraine by emphasizing potential environmental risks from the use of certain types of weapons (e.g., depleted uranium shells).[17] The third is the deliberate escalation of panic within society through the manipulation of unverified data, aimed at forcing Ukraine to make concessions.[18]

Moreover, unintentional misinformation can arise from methodological errors in assessing the ecological consequences of war. Among the main issues, one can highlight incorrect comparisons of pollution indicators with standards, which prevent a proper evaluation of the impact of recent military actions.[19] Moreover, the absence of up-to-date basic data regarding the background levels of chemical elements in the various regions of Ukraine,[20] as well as the difficulties in distinguishing the impact of military actions from other factors, such as intensive agriculture, mining, and industry before the war or natural phenomena, complicates the accurate assessment and attribution of pollution and environmental damage caused by the war.

All of this contributes to myths about the current state of Ukrainian agriculture. The first myth claims Ukraine lacks mechanisms for environmental damage assessment and compensation, with outdated soil standards (i). The second alleges that much arable land is now unusable due to contamination (ii). The third suggests Ukraine's agricultural sector is in long-term decline and will take decades to recover (iii).

Here, we critically analyze the war's impact on Ukrainian agriculture and soils. The analysis will be based on current data from environmental legislation, statistical

[17] Zakharova (2023).

[18] Khudoliy (2022).

[19] Weir et al. (2024).

[20] Filho et al. (2024).

data, laboratory tests, and Ukrainian and international soil assessment standards. The working hypothesis is that by using modern restoration methods, implementing effective state programs, and attracting international support, Ukraine has significant chances to restore and effectively modernize its agricultural system, maintaining its status as one of the key global food suppliers.

Myth 1. In Ukraine, There Are No Mechanisms for Assessing the Damage Caused to Soils and Compensation Methodologies, and Environmental Standards Regarding the Content of Heavy Metals in Soils Do Not Meet International Norms

Before the start of the full-scale invasion by the Russian Federation, the Law of Ukraine on Land Market came into force,[21] aimed at optimizing land use and preventing soil degradation.[22] This land reform, which allowed individuals and legal entities to acquire land plots as property, was one of the most extensive and complex reforms in the country's history.[23] However, the outbreak of the war in 2022 significantly disrupted its implementation, creating substantial obstacles for the land market, particularly in areas affected by occupation, contamination, or destruction.[24]

According to data from the Ministry of Agrarian Policy, approximately 30% of Ukraine's land is either in an active combat zone, has been mined, or is potentially contaminated with toxic substances.[25] This has led to significant difficulties in conducting agricultural activities and managing land resources. In the occupied territories, legal norms concerning land ownership are systematically violated through the forced confiscation of land by occupiers, restricting landowners' access, making it impossible to cultivate or lease, as well as through illegal agricultural use by third parties, with harvests appropriated without consent or compensation. These actions not only violate the rights of landowners but also cause significant economic losses.

In addition to direct financial losses, the risk of soil contamination with heavy metals and other toxic substances and physical damage from explosive munitions has raised concerns about the safety of Ukrainian soil for agricultural use. This has raised alarm among international traders, particularly regarding the potential decline in exported food quality from a country experiencing active conflict.[26] The disruption of food supply chains can lead to economic breakdown and heightened risk of hunger in countries dependent on Ukrainian food supplies. The consequences could extend further, potentially triggering a wave of refugees from affected regions. These concerns highlight the importance of state control mechanisms over soil quality in Ukraine.

[21] Verkhovna Rada of Ukraine (2021).

[22] Wikipedia Contributors (2025b).

[23] Livićka (2023).

[24] Denysenko and Shapovalova (2024).

[25] Basanec (2024).

[26] Torero Cullen (2023).

Before the full-scale invasion, Ukraine's legislation was not adapted to wartime conditions. The suitability of soils for agriculture was assessed according to the Resolution of the Cabinet of Ministers of Ukraine dated December 15, 2021, No. 1325,[27] which defines the standards for the Maximum Allowable Concentrations (MACs) of hazardous substances in soils. Control over compliance with these regulations was managed by the State Environmental Inspectorate of Ukraine, which conducted soil quality checks and issued recommendations to prevent further pollution. The State Geocadaster, in turn, provided monitoring and cadastre data to identify critical pollution zones. The document includes a list of 39 harmful substances,[28] the monitoring of which aims to prevent pollution and support sustainable agricultural development. These mechanisms are still in effect today.

It is worth noting that Ukrainian regulations regarding the concentration of heavy metals in soil are more stringent than international standards.[29] However, these standards do not take into account the context of the natural background of heavy metals, as in some regions of Ukraine, the concentration has historically been higher than the established MACs. Furthermore, the threshold standards cannot be used to assess the damage caused by combat activities, as this requires comparing the state of the soil before and during/after the war. They also cannot be used to assess the cost of soil restoration, as in some regions of Ukraine, the natural concentration of certain elements is higher than the MACs. The need to revise the MACs arose before the war due to the significant diversity of soils (over 650 different types and subtypes), and today, this issue is even more relevant, as the development of a post-war soil restoration strategy is imminent. This strategy includes an essential component of soil mapping to determine which areas are suitable for agricultural activities, which require restoration after being damaged, and which should be temporarily withdrawn from use due to high levels of contamination.

Despite the fact that the current legislation of Ukraine does not yet cover all aspects of the consequences of military actions, since 2022, Ukraine has taken a number of steps towards addressing the environmental consequences of the war. In particular, on March 1, 2022, an Operational Headquarters was established under the State Environmental Inspectorate of Ukraine to document, organize information, and create a unified register of environmental damage caused by the Russian Federation's invasion of Ukraine. Additionally, a number of important documents were adopted:

- Resolution No. 783 dated July 28, 2023, which regulates the recording of environmental damage;[30]
- Resolution No. 326 dated March 20, 2022, on determining the damage caused by the armed aggression of the Russian Federation;[31]

[27] Shmyhal (2021).

[28] Verkhovna Rada of Ukraine (2021).

[29] FAO (1992), Lexinform (2022), World Health Assembly (1996).

[30] Official Web Portal of the Parliament of Ukraine (2023a).

[31] Official Web Portal of the Parliament of Ukraine (2023b).

- Order of the Ministry of Agrarian Policy No. 295 dated May 18, 2022, which approves the methodology for assessing damages to the land fund.[32]

The main electronic source for recording damages today is the "Unified Environmental Platform EcoSystem."[33] This is a nationwide automated information and analytical system that provides access to environmental information and functions as a network for creating, collecting, receiving, storing, using, disseminating, protecting, and safeguarding data. One of the functional modules of the platform is the "EcoThreat" service, which ensures the recording of environmental damage caused by emergencies, events, or armed aggression by the Russian Federation. Farmers can quickly report soil damage using the "EcoThreat" website or mobile app.[34] They can upload photos and video recordings and specify the location using geodetic coordinates. The State Environmental Inspectorate processes requests and determines whether to accept or reject them within one day. Accepted requests proceed to the next stages of the process, which include conducting inspections, verifying details, calculating damage, and informing the applicant of the review results through an electronic account.

The primary document regulating the determination of damage and losses caused to agricultural producers as a result of military aggression is the Resolution of the Cabinet of Ministers of Ukraine, dated March 20, 2022, No. 326, "On approval of the Procedure for determining the damage and losses caused to Ukraine as a result of armed aggression by the Russian Federation."[35] According to this document, local state administrations (military administrations during the period of martial law), executive committees of villages, settlements, and city councils have the right to conduct analytical and standardized assessments of damage and losses. The document defines:

- Classification of damages, which includes direct material losses, lost profits, costs for the restoration of damaged objects, as well as environmental damage;
- Responsible authorities, including executive authorities, local government bodies, military administrations, and other authorized structures;
- Assessment mechanism, which includes conducting an expert monetary evaluation of objects, analyzing the extent of the damage caused, and determining the cost of its compensation; and,
- Formation of documentation for the assessment, based on inspection reports, project-estimate documentation, accounting records, cadastral data, and other documented information.

[32] Official Web Portal of the Parliament of Ukraine (2022a).

[33] Official Web Portal of the Ministry of Environmental Protection and Natural Resources of Ukraine (2024).

[34] Beckmann et al. (2022).

[35] Official Web Portal of the Parliament of Ukraine (2023c).

The second important document is the "Methodology for Determining the Damage and Losses Caused to the Land Fund of Ukraine,"[36] which outlines a comprehensive procedure for assessing losses, including lost profits, costs for reclamation, the restoration of reclamation areas, and returning agricultural land to a usable condition. The entities tasked with conducting the assessment are regional administrations or military administrations while under martial law. As of January 1, 2025, these regulatory documents have enabled the calculation of damage inflicted on land resources due to the armed aggression of the Russian Federation, amounting to €27.38 billion.[37] Despite such advances in the legislative system, there are still a number of unresolved issues:

- The absence of a complete database on the state of soils before the war;
- The lack of clear procedures for the reclamation and reintegration of contaminated lands into economic circulation;
- Legislative conflicts, particularly the ambiguity of the concept of "reparations" in domestic law; and,
- The absence of financial mechanisms to compensate landowners and agricultural enterprises for losses.

The issues listed above are individual gaps in Ukrainian legislation that may create obstacles to enabling reparations and financial assistance in soil restoration and should be addressed as soon as possible.

Therefore, it is critically important to collate all available data on the pre-war condition of soils, revise legislative terminology, develop remediation methods for soils with varying levels of damage, and refine the mechanism for assessing financial damage caused to soils as a result of hostilities. This will ensure compensation for losses, gain international recognition, and serve as an evidentiary basis for reparations at the UN Compensation Commission. Environmental crimes are notoriously difficult to prove in international courts. For example, after the Gulf War (1990–1991), Saudi Arabia received only 6.3% of the total environmental reparations it claimed.[38]

The state's primary focus should be on studying the requirements for evidence collection and the methods for gathering evidence, proving causal relationships, and calculating the specific environmental damage caused by military actions. Relevance of the evidence and its significance are fundamental criteria.

According to international law, damage documentation should be objective and independent, with separate parties responsible for forming an impartial basis. Additionally, it should comply with Ukrainian legislation and align with internationally accepted methods for assessing environmental damage, as recognized by international courts.

[36] Official Web Portal of the Parliament of Ukraine (2022b).

[37] Agropolit (2025).

[38] CEOBS (2016); Wikipedia Contributors (2025d).

To ensure monitoring and assessments recognized by international institutions, an independent international body should be established as soon as possible, engaging relevant experts in the field of soils before the end of the Russian-Ukrainian war.

Myth 2. A Significant Portion of Arable Land Will Become Unusable Due to Excessive Pollution, Mechanical Damage, or Increased Radiation Levels

After February 24, 2022, Ukrainian scientists faced many new challenges in carrying out their work, including those in the field of soil science. The war changed the research approach, requiring a rapid analysis of soil conditions contaminated by combat actions. The first field studies began in 2022, covering the north, east, and south of Ukraine.[39] Scientists from Ukraine, the United Kingdom, Switzerland, Poland, and other countries have identified key research areas, including the analysis of craters from explosions, missile impact sites, oil spill zones, and locations of burned military equipment.[40] Sampling methods were adapted,[41] data on the impact of the war on soils were systematized, and normative indicators demonstrating changes in the soil cover were established.[42]

In the first year of the war, a foundation was established for studying the military impact on soils; the second year focused on systematizing the collected data and formulating the initial conclusions; and the third year commenced the process of mapping and developing a post-war recovery strategy.

Research has shown that although combat activities significantly affect soils, their impact is heterogeneous. With the onset of the full-scale Russian invasion, scientists began soil sampling to establish situational awareness in areas of military influence. Agrochemical indicators usually assessed during routine soil analyses did not show significant changes; thus, they were omitted from further consideration. The focus of subsequent analyses shifted to heavy metals such as lead, arsenic, cadmium, antimony, nickel, and zinc. These potentially toxic elements, introduced through military activities, can disrupt soil ecosystems, impact plant health, and pose risks to human and animal populations. They can be introduced to soil from military ordnance, including ammunition, grenades, and missile explosions, and can persist in the environment for extended periods due to their non-degradability.

The deposition of heavy metals in war-affected soils presents serious environmental and health risks.[43] The mobility of heavy metals is largely dictated by soil characteristics, including pH, cation exchange capacity (CEC), and soil organic matter (SOM) content.[44,45] In acidic and low-SOM soils, heavy metal mobility is enhanced, increasing the likelihood of uptake by plants and their subsequent entry

[39] Solokha et al. (2022a).

[40] Splodytel et al. (2023).

[41] Datsko et al. (2024).

[42] Solokha et al. (2024).

[43] Bonchkovskyi et al. (2025).

[44] Broomandi et al. (2020).

[45] Beiyuan et al. (2017).

into the food chain.[46] Studies conducted in conflict zones, such as Gaza, have demonstrated significant heavy metal contamination in agricultural soils, leading to crop failures and potential health risks for populations consuming produce from affected areas.[47] In Ukraine, where Chernozem soils (black soil) are predominant and characterized by neutral to slightly alkaline pH, high SOM content, and high CEC, the mobility of heavy metals may be somewhat restricted, though long-term contamination risks remain a critical concern.[48]

The initial 2 years of research primarily concentrated on analyzing craters and pits, under the assumption that these regions would present a considerable risk of chemical contamination from heavy metals and suffer intense soil compaction. The research was conducted by Sumy National Agrarian University in six regions of Ukraine within the combat zone or bordering it.[49] Based on the analysis of over 3000 samples, minor exceedances in the concentrations of heavy metals, such as tin, sulfur, cadmium, antimony, zirconium, titanium, and cobalt, were found. However, the natural variability of the soil's chemical composition complicates a definitive link between these deviations and military actions. The slight increase in concentrations above background levels does not classify the soils as contaminated. In a small percentage (less than 2%), significant exceedances in concentrations of elements such as mercury and silver (up to several times the MAC) were recorded. This may result from military activity and natural anomalies, fertilizer use, or contamination from surrounding industrial sources.

Crater explosions are primarily considered a physical soil degradation factor. They cause the overturning of soil layers, surface subsidence, and the development of erosion processes. However, expected soil compaction in the areas of craters was not observed; on the contrary, loosening of the soil was noted in the centers and on the slopes of the craters. Overall, preliminary results indicate that agricultural production may be possible in most areas, provided that there is careful monitoring of crop growth.

In the second stage, scientists focused on studying the sites of burnt military equipment, rockets, and air bombs. Subsequently, this allowed narrowing the selection of soil sampling areas and optimizing the sampling network depending on the different types of impact on the soil cover. After the field expeditions by specialists from the National Scientific Center "Institute for Soil Science and Agrochemistry Research named after O.N. Sokolovsky," the sequence and degree of change in stable soil indicators, such as geochemical and granulometric composition, were identified.[50]

The sites of burned military equipment were characterized by significantly higher levels of contamination, although with much lower density compared to

[46] Thalassinos et al. (2023).

[47] Manduca et al. (2017).

[48] Vysloužilová et al. (2016).

[49] Datsko et al. (2024).

[50] Solokha et al. (2022b, 2024).

craters. According to preliminary estimates, both sides of the armed conflict (Ukraine and the Russian Federation) have lost approximately 8000 units of heavy machinery over three years of the war, while the number of craters is several tens of millions. The highest exceedances of the MAC were recorded for lead, zinc, and cadmium. The maximum levels of contamination were noted in the soil beneath the wreckage of the T 72B3 tank, where lead exceeded the MAC by 38.9 times, zinc by 7.4 times, cadmium by 8.5 times, and copper by 4 times. In samples from the wreckage of the T80 tank, lead exceeded the MAC by 78.8 times, zinc by 8.7 times, and the wreckage of a T72 "Solntsepek" launcher showed lead exceedance by 54.4 times and zinc by 1.4 times. The main pollutants are distributed as follows: lead > zinc > cadmium > copper. The higher level of contamination emphasizes the need for reclamation of these areas before they can be reused in agriculture.

The preliminary research results indicate that the most affected areas should be temporarily removed from commercial use; however, there may be no need to remove entire fields from cultivation. In less affected areas, crop cultivation can continue with the implementation of control measures.

Research from the Ukravit Institute confirmed that different Ukrainian crops will accumulate heavy metals in different amounts, necessitating a careful approach to selecting plants for cultivation. Legumes are the least susceptible to cadmium accumulation, while cereals, lilies, umbrella plants, and gourds show a medium level. In contrast, crucifers, amaranths, nightshades, and asters can accumulate significant amounts. Leafy vegetables and fodder crops contain more heavy metals compared to legumes, cereals, and industrial crops, highlighting the need for further research and the implementation of monitoring measures.[51] Peas can significantly accumulate heavy metals, in particular iron and chromium, in the conditions of the Forest Steppe conditions in Ukraine.[52]

Another important aspect of the research is the effect of military vehicles on soil compaction. It has been established that significant compaction can reduce crop yield by 40–60% in the following years.[53] This effect is especially observed in fields of prolonged combat operations, where heavy equipment has moved for a month or more. However, the active application of agrotechnical measures can return soil to normal conditions within 1–2 years.[54]

Owing to the presence of minefields and the inability to conduct field research, various forms of military degradation have been identified remotely using satellite technology data. Different types of military degradation were proposed and successfully classified using satellite images,[55] which could later be widely used to assess the suitability of agricultural land and ensure the country's food supply and food security.

[51] SuperAgronom (2024).

[52] Trotsenko et al. (2024).

[53] Lystopad (2024).

[54] Chaika and Korotkova (2023).

[55] Lebed et al. (2024).

It is important to highlight another pressing issue of extensive debate in society—the use of depleted uranium shells, which may pose a potential risk to soil contamination. These shells, developed in the USSR as BOPS "Vacuum-2" and "Grifel-1/2," are used by armored and artillery forces.[56] After the arrival of M1 Abrams and Challenger tanks, depleted uranium armor-piercing shells were used in Donetsk and later in the Kursk region. Discussions about their radioactivity are ongoing, but there are no scientific studies on their impact on soils in Ukraine. A survey of potential contamination should be conducted in active combat zones, which are currently inaccessible. As for the direct threat to human health, depleted uranium does not directly expose individuals in its vicinity to significant radiation doses. Its radioactivity is approximately 40% lower than natural uranium and cannot typically penetrate skin or clothing. At a distance of one meter, one kilogram of depleted uranium emits an annual radiation dose approximately equivalent to only a third of natural background radiation exposure.[57] However, prolonged exposure at close range can potentially damage genetic material and increase the risk of cancer.[58]

Despite challenges, the soil cover of Ukraine currently demonstrates resilience to anthropogenic impacts, and no catastrophic changes have been recorded in preliminary studies. At the same time, continuous monitoring remains critically important, as even minimal shifts in chemical composition can affect ecosystems.[59] Specifically, changes in pH levels are a key factor in regulating the mobility of heavy metals. An alkaline environment promotes the formation of metal-organic complexes, which increases the mobility of lead, copper, and nickel.[60]

Thus, military activity causes local soil contamination, but its impact on crops is uneven. To ensure food security and comply with international standards, continuous monitoring of heavy metal content in soils and products is necessary, especially in regions of active combat. Expanding research, mapping, monitoring, and management of environmental risks related to agricultural lands in Ukraine is important. This will allow for better assessment of soil conditions, prevent contamination from transferring to plants and food products, and contribute to the sustainable development of agriculture. Post-war soil condition research is an investment in the future of Ukraine's agricultural sector, ensuring safe and sustainable farming practices for future generations.

Myth 3: Ukraine's Agricultural Sector is in Critical Stagnation, and Its Recovery Will Take Decades

The war has dealt a serious blow to agriculture, especially to small and medium-sized farms of generally up to 200 hectares, which rely on their own resources and funding. According to the World Bank, the value added by Ukraine's agricultural sector dropped by 23% in 2022 compared to the 2016–2021 average. This

[56] Center for Countering Disinformation (2023).

[57] Weiss (2021).

[58] Shaki et al. (2019).

[59] Splodytel et al. (2023).

[60] Wnuk (2023).

disruption also affected crop production, with wheat output falling by 15% and maize production dropping by 26% in 2022/2023. Additionally, the conflict led to a 22% decrease in arable land available for agriculture in 2022, further compounding the challenges faced by the sector.[61] The main challenges for agricultural producers can be summarized as:

- Physical destruction of agricultural infrastructure and land.[62] Although the military actions did not lead to the widespread land contamination that was initially feared, they still caused significant damage and destruction of irrigation systems, elevators, warehouses, farms, and logistics facilities. The consequences of shelling and explosions included the formation of craters in arable lands, spills of petroleum products, and chemical soil contamination in areas where military vehicles were burned, which significantly complicates the restoration of agricultural production and requires comprehensive measures for environmental land rehabilitation.
- Hydrological and soil degradation. The destruction of the Kakhovka Hydroelectric Power Station on June 6, 2023 led to catastrophic consequences for farmers in the south and southeast of the country, including flooding 5000 hectares of arable land, and the subsequent draining of 80% of the Kakhovka Reservoir area, leaving behind 2000 km^2 of unstable sandy-clay soils prone to erosion.[63]
- The alienation of territory as a result of occupation or active combat operations. The war has conditionally divided Ukraine into several zones depending on the level of security for agricultural production (Fig. 1).

As of today, 109,000 km^2 of Ukrainian territory remain under occupation, while the Armed Forces of Ukraine have liberated approximately 39,000 km^2 since the beginning of the full-scale invasion.[64] Currently, five regions of Ukraine and the Autonomous Republic of Crimea are under partial occupation. Specifically, these are Luhansk (26,300 km^2, or 98% of the territory), Zaporizhzhia (19,600 km^2, or 73%), Kherson (20,500 km^2, or 72%), Donetsk (15,070 km^2, or 57%), and Kharkiv (603 km^2, or 2%) regions. In addition, Russia fully controls the Ukrainian peninsula of Crimea, which has an area of 26,900 km^2.[65]

- Minefields: In the past 3 years, the area of mined land has totaled approximately 139,000 km^2, a significant portion of which consists of agricultural land.[66] In certain regions, the mine density reaches 4–5 units per square meter, rendering Ukraine one of the most affected countries globally with explosive hazards, sur-

[61] Nivievskyi et al. (2024).

[62] Kulish (2024).

[63] UN Environment Programme (2023).

[64] Den'kovych (2023).

[65] Onisymova (2023).

[66] Verkhovna Rada of Ukraine (2025).

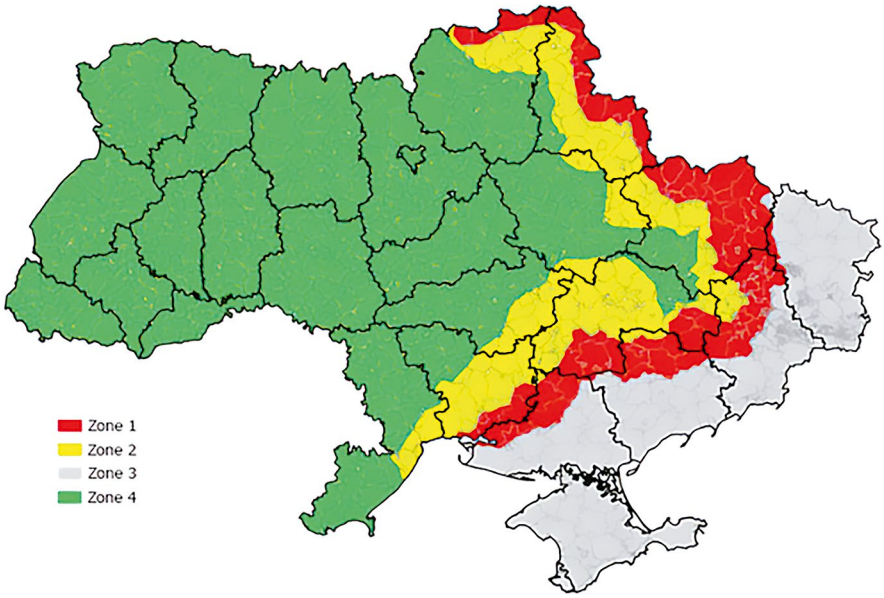

Fig. 1 Zoning of the territory of Ukraine according to the impact of hostilities: Zone 1—Combat zone, high risk for agricultural production. Production is not carried out due to high risk levels or a direct ban (in occupied territories and combat zones); Zone 2—High-risk zone for agricultural production. Production can be carried out with certain restrictions and safety measures (in areas distant from combat zones); Zone 3—Occupied zone. Agricultural production is not possible due to high risk or a direct ban (in occupied territories); Zone 4—Relatively safe zone for agricultural production (The map is the authors' own development. The information is based on data from https://deepstatemap.live/, taking into account the front line, the intensity of hostilities, the ability of farmers to work under different conditions, as well as surveys of farmers and volunteers.)

passing both Afghanistan and Syria.[67] Despite pessimistic forecasts that full demining could take hundreds of years, Ukraine made significant progress in 2023–2024 thanks to active international support. In 2023, 18,000 square kilometers of agricultural land were cleared of mines, where 1 million tons of grain can now be grown. In 2024, sapper teams returned another 2850 km^2 to operation. Since the start of the full-scale invasion, approximately 35,000 km^2 of Ukrainian land have been cleared. As a result, farmers could reuse their cleared land, contributing to an increase in grain production.[68] However, despite success in demining such significant territories, it remains an extremely complex and prolonged process. Official sapper units are primarily focused on clearing critically important objects, including power lines, roads, and residential areas, leaving farmers uncertain about when their lands will be returned to agricultural

[67] Slovo (2023).

[68] Cabinet of Ministers of Ukraine (2023).

use.[69] Due to delays in demining, some farmers resort to using unqualified "amateur sappers," which can be extremely dangerous and ineffective. Many mines, including plastic anti-tank mines, cannot be detected by standard metal detectors, which increases the risk of accidents and complicates the safe use of land.

- Loss of access to markets: Due to the blockade of ports and destroyed logistics routes, farmers have lost the ability to export products at levels typical for the pre-war period.[70] The total cargo turnover of seaports in 2022 decreased by 61.4% compared to 2021, and the shipment of export goods reduced by 59.5%. In 2022–2024, Poland temporarily blocked borders for Ukrainian agricultural products, creating additional difficulties for exporters.
- Direct financial losses due to Russia's appropriation of Ukrainian grain have exceeded €680 million.[71] In addition, the war has restricted farmers' access to financing. Interest rates on loans have increased, and support programs often do not cover production costs. Furthermore, many farms have lost income due to the inability to sell their products.
- Before the full-scale war, the cost of transporting grain to Ukrainian ports was about ₴30–35 (€0.68–0.79) per ton. After the blockade of seaports and the shift to alternative routes to EU ports, particularly in Poland and Romania, this cost increased to ₴180–200 (€4.08–4.53) per ton as of August 2022.[72]
- The reduction in the workforce due to mobilization, evacuation of the population, and overall labor shortages has significantly impacted agricultural enterprises.[73] The labor shortage complicates seasonal tasks such as sowing, harvesting, and soil cultivation, leading to lower crop yields.
- The remaining workers face heavier workloads, resulting in fatigue and reduced productivity. Additionally, the loss of skilled workers with specialized knowledge and the rising costs of recruitment further deepen the crisis.

Despite these difficulties, demining continues, farmers are working to clear land and restore soil health, and the Ukrainian government has set an ambitious goal—to return 80% of contaminated territories to productive use by 2033. This will be an important step toward the restoration of the agricultural sector and the country's food security.

However, the full recovery of Ukraine's agricultural sector after the war is expected to be a long-term process, potentially taking up to two decades. Forecasts indicate that by 2040, the country will return to pre-war production levels of sunflower, barley, and wheat, while full recovery of crops like corn, rye, oats, and rapeseed is expected by 2050.[74]

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[69] Pavlenko (2023).

[70] Mokryakov (2023).

[71] Berestenko (2023).

[72] Currency exchange rate for 03.05.25: €1 = ₴43.7, sourced from https://minfin.com.ua/ua/currency/converter/.

[73] Bohdanyuk and Mandych (2024).

[74] SuperAgronom (2023).

However, achieving this recovery will require substantial investments. Current estimates indicate a need for approximately €52 billion for the restoration of the agricultural sector and an additional €30 billion for demining to ensure the safety of arable land.[75]

So, what important initial steps could the state take today to help support Ukrainian farmers?

- Reducing the financial burden on farmers: Introducing a reduced level of taxation for farmers in affected regions, providing legal support for documentation preparation, restoring property rights, and resolving disputes. Additionally, offering state guarantees for the purchase of machinery and equipment will reduce financial risks and contribute to the modernization of farms.
- Developing new financial mechanisms for farmers: Introducing lending at minimum rates, leasing programs for equipment purchases, and state support for land rent payments and buyouts. The creation of financial funds and specialized banking programs will support the restoration of farmers' activities, farm development, and infrastructure modernization.
- Establishing production cooperatives: Enabling farmers to pool resources and access agricultural services at preferential prices. Members of cooperatives will benefit from shared access to equipment, modern machinery, and technologies, reducing individual operational costs.
- Providing technological support for farmers: Ensuring farmers have access to modern technological solutions, including the latest equipment, digital farm management tools, and innovative agricultural technologies. This will help optimize resources, reduce costs, and restore farming operations.
- Introducing material support mechanism for farmers: Implementing a system that provides material assistance in the form of seeds, pesticides, fertilizers, fuel, and other essential resources. This will ensure the timely execution of agricultural operations, increase productivity, and facilitate farm recovery.

It is crucial to establish strong communication between the government and foreign donors to properly allocate ministerial responsibilities to revitalize Ukraine's agricultural economy. Given the substantial harm the ongoing violence has caused to farms, effective coordination between governmental entities and foreign organizations is essential to ensuring the effectiveness of recovery operations.

The Ukrainian government has established several collaborations to address key challenges, including demining operations, agricultural restoration, and environmental damage studies. These programs rely on financial and technical assistance from numerous contributors, each playing a unique role in the revival of agriculture.

As previously discussed, the future of Ukraine's agricultural sector depends on overcoming the challenges posed by landmine contamination, reclaiming deoccupied territory, and using sustainable techniques to develop a more resilient and modern agricultural landscape.

[75] Albaladejo Roman (2024).

Recognizing the magnitude of the issue, Ukraine has set an ambitious goal of demining all mine-contaminated lands by 2033, at a cost of €32.4 billion. To guide these efforts, the Ukrainian government has adopted the National Mine Action Strategy.[76]

Given the vast scope and financial burden of demining, international support has been crucial in advancing these efforts. Several funds and organizations have stepped in to provide financial assistance, technical expertise, and operational support.

One of the key contributors is The HALO Trust, a leading international demining organization actively working in Ukraine to clear hazardous land and improve safety in agricultural areas. In 2024, it became the first international operator authorized to use explosives to destroy ordnance in situ, significantly increasing the efficiency of clearance operations. Additionally, the organization has integrated drone and satellite technology to accelerate mine removal efforts.[77]

Since 2015, the Swiss demining organization FSD (Foundation Suisse de Deminage) has been actively involved in mine risk education and demining operations. Following the 2022 invasion, it expanded its work to include large-scale clearance of agricultural land in heavily affected regions like Chernihiv and Kharkiv.

The United States government has also played a major role in humanitarian demining operations.[78] Between 2004 and 2021, the U.S. contributed over €71.8 million toward landmine clearance and unexploded ordnance removal. Further strengthening these efforts, in July 2023, the U.S. Department of State donated €5.4 million worth of demining equipment to Ukraine's State Special Transport Service.[79] Sustaining U.S. financial investment for demining efforts in Ukraine is crucial in building global capacity for research, mapping, and monitoring environmental risks on agricultural lands.[80]

In addition to direct demining efforts, financial and strategic backing has been provided by organizations such as the United Nations Development Programme (UNDP). With support from the governments of the Netherlands, Switzerland, and the United Kingdom, UNDP has explored innovative financing solutions, including

[76] Kitsoft (2024).

[77] The HALO Trust (2025).

[78] U.S. Embassy in Ukraine (2024).

[79] Currency exchange rate for 03.05.25: €1 = $1.04, sourced from https://minfin.com.ua/ua/currency/converter/.

[80] Melnyk and Koulabdara (2025). By the time of writing this chapter, the Trump administration had imposed a 90-day freeze on foreign aid, including humanitarian demining programs.

Sustainability-Linked Bonds[81] and Outcome-Based Public-Private Partnerships,[82] to fund demining operations and support Ukraine's National Mine Action Strategy.[83]

Other international organizations have also contributed to demining and humanitarian relief. ITF Enhancing Human Security, a Slovenian non-profit organization specializing in landmine clearance and post-conflict reconstruction, has supported Ukraine by providing risk education, victim assistance, and operational support.[84]

Meanwhile, United24, a fundraising platform launched by the Ukrainian government, has been instrumental in collecting donations to support Ukraine's defense, humanitarian aid, and demining initiatives. Funds raised through United24[85] are allocated to relevant ministries to ensure the efficient execution of demining operations and to enhance safety in affected communities.[86]

The recovery of the agricultural sector, a key driver of both the national economy and global food security, is projected to cost around €52.1 billion, with an additional €29,7 billion required for demining operations.[87] This includes financial support for small producers and the promotion of sustainable agricultural practices aligned with EU standards.

In addition, Ukrainian authorities aim to restore agricultural production in recently de-occupied territories to pre-war levels during 2025, with a diversification of crops driven by the challenges of landmines and the loss of fertile land. Non-traditional crops, such as flax and peanuts, are being explored due to the declining profitability of staple crops like corn.[88]

Thus, Ukraine's agricultural recovery is closely intertwined with effective demining operations and the restoration of de-occupied territories, which will be critical to revitalizing the agricultural sector and ensuring long-term food security.

In addition to the challenges posed by mined lands, Ukraine's agricultural sector faces many other significant issues that the ongoing conflict has exacerbated. These include a sharp reduction in crop yields, the degradation of soil quality, severe economic losses, and disruptions to livestock farming. Each of these problems has created a complex web of challenges for farmers, making it increasingly difficult to maintain agricultural output and sustain livelihoods.

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[81] A Sustainability-linked bond is a fixed income instrument where its financial and/or structural characteristics are tied to predefined Sustainability/ESG objectives (Chauhan and Kour 2024).

[82] Outcomes-based partnership is a collaboration where funding is tied to the achievement of measurable results, rather than inputs, enabling effective and impactful public service delivery (Global Steering Group for Impact Investment 2023).

[83] UN Development Programme (2024).

[84] Wikipedia Contributors (2024).

[85] UNITED24 is a fundraising platform launched by President Volodymyr Zelenskyy as the main venue for collecting charitable donations in support of Ukraine. Funds are transferred to the official accounts of the National Bank of Ukraine and allocated by assigned ministries to cover the most pressing needs (Government of Ukraine 2022).

[86] Wikipedia Contributors (2025c).

[87] Bogonos et al. (2023).

[88] Seed World Group (2025).

Facing these challenges, several organizations have stepped in to provide support, although the broader problems remain far from resolved. The World Bank, for example, has launched initiatives like the "Seeds of Hope" program to provide much-needed financial assistance to small farms affected by the conflict.[89] Similarly, USAID has mobilized over $510 million (USD) through its AGRI-Ukraine initiative, which supports more than 14,000 farmers by offering seeds, fertilizers, storage solutions, and financial backing. This funding also includes grain storage solutions capable of holding up to 5.5 million tons of grain to help mitigate logistical challenges caused by the ongoing conflict.[90] USAID launched its Agricultural Resilience Initiative-Ukraine (AGRI-Ukraine), mobilizing over $510 million (USD) to support over 14,000 farmers. This initiative provided much-needed resources, including seeds, fertilizers, and storage solutions, while also offering financing to bolster Ukraine's agricultural resilience. Additionally, USAID introduced grain storage solutions with a capacity to hold up to 5.5 million tons, addressing the urgent logistical challenges farmers were facing.[91] Organizations like Seeds of Hope, which have also stepped in to provide assistance, have been critical in offering financial and logistical support to farmers in the hardest-hit regions. Through initiatives that offer grants, feed, and other necessary resources, Seeds of Hope has made a difference in alleviating some of the burdens Ukrainian farmers face. While these programs offer valuable relief, the long-term recovery of Ukraine's agricultural sector will depend on broader peace and stabilization efforts. Despite the recent freeze on American aid, which has highlighted the unreliability of certain funding sources and their dependence on political will, initiatives like Seeds of Hope—providing grants, feed, and other essential resources—play a crucial role in easing the burdens faced by Ukrainian farmers.[92]

The World Bank has launched the Ukraine Agriculture Recovery Inclusive Support Emergency (ARISE) Project. This initiative is designed to assist over 90,000 farmers by providing access to affordable loans and grants, ensuring they have the necessary resources to continue agricultural production despite the challenges caused by the war. Additionally, the Ukraine Relief, Recovery, Reconstruction, and Reform Trust Fund (URTF) has been established to support long-term recovery efforts, including restoring agricultural infrastructure and implementing flexible programs tailored to Ukraine's evolving needs.[93] Alongside these international efforts, Ukrainian environmental organizations are playing a vital role in assessing the damage and advocating for sustainable recovery. Groups such as the Ukrainian Nature Conservation Group, Ecopark Osokorky, Environment-People-Law (EPL), Save Dnipro, and Ecoaction are actively monitoring the environmental impact of the war, promoting soil restoration projects, and pushing for stronger environmental

[89] FAO (2023).

[90] International Food Policy Research Institute (2023); Welsh and Dodd (2025).

[91] Interfax-Ukraine (2024).

[92] Melnyk and Koulabdara (2025).

[93] World Bank (2025).

protections. Supporting these NGOs is essential for ensuring long-term environmental recovery in Ukraine, as they provide on-the-ground expertise and advocacy.[94]

With millions of hectares of farmland damaged and countless farmers struggling to recover, the combined efforts of international financial institutions, demining organizations, and environmental NGOs are crucial in addressing the long-term consequences of soil degradation.

While these initiatives offer hope, Ukraine will need sustained global support to restore its agricultural sector and prevent further environmental damage.

3 Conclusion

The ongoing Russian war against Ukraine, which escalated in February 2022, has profoundly affected the country's agricultural sector, a pillar of its national economy and global food security. The war has caused extensive environmental damage, including soil degradation, destruction of infrastructure, and widespread minefields, rendering large areas of arable land unusable. This disruption has weakened Ukraine's ability to maintain its role as a key global grain exporter, particularly to regions in Asia and Africa that rely heavily on its agricultural products. Ukraine has long been a vital player in global food production, serving as one of the world's largest grain exporters. Additionally, the war has exacerbated pre-existing environmental challenges, complicating recovery efforts.

A significant concern is the potential contamination of soil with heavy metals and other toxic substances resulting from military activities. These contaminants persist for extended periods, posing serious risks to human health and agricultural productivity. While early studies suggest soil contamination may not be catastrophic, long-term effects remain uncertain, making ongoing monitoring essential to safeguard food safety and environmental health.

The war has also led to massive economic losses for Ukrainian farmers, with estimates indicating nearly €32 billion in damages to the agricultural sector. Destroyed irrigation systems, storage facilities, and transportation infrastructure have further disrupted agricultural production and exports. Additionally, the occupation of key agricultural regions and landmine contamination have created major obstacles to recovery. However, Ukraine has made significant progress in demining, with international support playing a key role in clearing hazardous areas and restoring agricultural land.

Misinformation campaigns have further complicated the situation, spreading false narratives about soil contamination and the viability of Ukrainian agricultural products, which undermine global confidence in the country's ability to remain a key food supplier. Addressing these disinformation efforts is critical to restoring Ukraine's reputation and ensuring its agricultural exports remain competitive in the global market.

[94] Ecoaction (2023).

The recovery of Ukraine's agricultural sector will require sustained domestic and international investment alongside innovative solutions to tackle soil contamination, land degradation, and logistical challenges. Developing new financial mechanisms, technological support, and cooperative farming models will be essential to modernizing operations and helping farmers recover. Ongoing global support for demining and environmental restoration will also be key to ensuring Ukraine's agricultural sector regains its strength.

Moreover, this support is not limited to short-term relief; it also aligns Ukrainian agriculture with EU standards, advancing the country's European integration. This convergence is vital for Ukraine's long-term recovery, strengthening trade, economic stability, and regional prosperity. These efforts lay the groundwork for a peaceful and resilient future, securing Ukraine's role in the global agricultural market and within the European community.

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