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# **Consequences of the Ongoing War in Ukraine on the Environment**

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# Abstract

In today's world, armed conflicts pose a growing threat not only to human society but also to the natural environment. The use of modern weaponry results in large-scale environmental crimes, as demonstrated by the war in Ukraine. This has driven the need for research focused on assessing the environmental consequences of military operations. The purpose of this research was to assess the environmental consequences of the war on soils, water resources and biodiversity. The focus of the study was the condition of Ukraine's natural environment in the context of ongoing military conflict. The methodological basis of the study is the dialectical principle of scientific knowledge and systematic analysis of environmental phenomena and processes. The study revealed significant losses of natural resources across Ukraine, particularly in regions experiencing ongoing hostilities. It quantified the extent of environmental damage and emphasized that these losses continue to escalate with each passing day of the war. The study found that full-scale hostilities have effectively halted all initiatives aimed at advancing the development of Ukraine's ecological economy. The extent of damage to soil, water resources, and the loss of flora and fauna provides ample justification to describe the situation in Ukraine as a huge environmental disaster. This crisis, while rooted in the war, poses serious risks with potential negative impacts on the European region's environment. Possible options for the restoration of the natural environment and their implications for the development of human society are identified, in particular, green recovery based on local priority actions.

# Keywords

Ecology; Biodiversity; Natural resources; Pollution; Soil; Water resources

# Introduction

The rapid pace of human industrial development over the past century has become a major factor in the emergence of critical environmental problems. The exploitation of non-renewable resources and the pollution caused by hazardous waste from industrial production and public consumption have resulted in a level of environmental toxicity that threatens the very survival of humanity. Massive environmental pollution and its ruthless exploitation have led to the destruction of natural diversity, the loss of a significant amount of non-renewable resources, and climate change. According to a biodiversity study conducted by a UN expert, 25% of all species on earth are under threat of extinction. A significant number of the world's inhabitants are already experiencing a shortage of drinking water, have problems with food supply and quality, and breathe polluted air (UNDP, 2020). According to UNESCO research, more than 2.2 billion people in the world (especially in Africa and Asia) do not have stable access to clean drinking water, and about 3.5 billion people have problems using water even for daily hygiene (The United Nations World Water Development Report, 2023). The result of environmental disruptions to the living environment for humanity has been an increase in diseases, problems with population reproduction, and a decline in quality of life. According to UNDP, more than 7 million people die every year due to air pollution alone (United Nations Development Programme, 2019). Therefore, solving the problems of greening society and forming a green economy is becoming one of the main factors in ensuring the quality development of human civilization in the future.

War itself is a critical factor in the destabilization of society, and modern warfare is also a significant threat to the environment. The use of modern weapons not only leads to the destruction of people but also destroys the world itself. For Ukraine, where an open military conflict has existed since 2014 and full-scale hostilities have been taking place on its territory since 2022, the military component of environmental disruption is becoming an increasingly acute problem for the country's development. According to the Ministry of Environmental Protection and Natural Resources of Ukraine, as of February 2025, 7,569 cases of damage to Ukraine's environment caused by military operations were documented, with an estimated amount of losses of over UAH 3.526 trillion (EcoZagroza, 2025; Filho *et al.*, 2024). It is worth emphasizing that the actual figures are much higher, as a significant part of the Ukrainian territory cannot be investigated for environmental damage due to hostilities, occupation and the constant increase in such losses.

Moreover, it should be emphasized that these problems are not only related to Ukraine, as the hostilities are spreading to the entire region and even the entire planet, deepening and exacerbating the global environmental crisis. For example, due to the destruction of forests in Ukraine, the level of greenhouse gas absorption potential has decreased by 1.7 million tons, and combustion products and emissions from the hostilities are spreading to a large part of European countries and have been recorded in Romania, Moldova, Bulgaria, Hungary, Latvia, Lithuania, Estonia, Serbia, Croatia, and Poland (Roztrjopa, 2024). That is why the problem of assessing the environmental consequences of war and identifying opportunities to overcome them requires significant research by both Ukrainian scientists and the international scientific community.

The study aims to assess the environmental impact of military operations on soil, water resources and biodiversity in Ukraine.

# **Literature Review**

Society's understanding of the fact that its activities have led to global environmental problems was consciously incorporated into scientific ideas in the mid-twentieth century, when industrialization led to large-scale destruction of the natural environment. In the scientific space, the awareness of the specifics of environmental problems on a global scale was first formed at the level of philosophical perception and understanding of this phenomenon, and then scientific research began to exert an appropriate, environmentally oriented influence on public consciousness, state and political, and supranational management activities.

The most influential scientific contribution to the study of environmental issues and elimination of the consequences of negative anthropogenic impact on nature was made by scientists who are members of a scientific non-political organization called the Club of Rome, which was founded in 1968, bringing together more than a hundred well-known environmental scientists from more than 30 countries. The research on the development of society, carried out by US scientists, Meadows *et al.* (1978). Forster and other scientists, in the form of a mathematical model that linked human development to changes in investment, resource use, environmental pollution and consumer production, shook the entire world community. The report predicted the timing of the depletion of key industrial resources, and they did not exceed 100 years (Meadows *et al.*, 1972; Nordhaus, 1973).

The result of scientific and political cooperation was increased attention to the distribution of exhaustible minerals and an understanding of the need for changes in scientific and technological development, demography, and attitudes toward nature. To prevent a global environmental catastrophe, the above-mentioned scientists, Meadows et al. (1972), proposed the concept of establishing a global balance between nature and humanity, focusing on social and economic changes for humanity that would ensure the preservation of nature. A significant contribution to the problems of ecology was made by Peccei (1977), whose report "Human Qualities" introduced ideas about the possibilities of the future existence of mankind and proposed projects for implementing practical measures to overcome existing global problems. It is worth noting that in the future, the world's ideas of ecological society development are transforming, and the main modern principle of research on this issue is the formation of environmentally oriented consciousness and general social responsibility. A significant contribution to the development of the ideas of overcoming environmental threats was made by such prominent scholars as Mesarovic and Pestel (1974), the study "Humanity at a Turning Point", László (1977) ("Goals of Humanity"), Weizsacker (1998) ("Factor Four"). A prominent member of the Club of Rome is a well-known Ukrainian, Havrylyshyn (1980) ("Guides to the Future: Towards More Effective Societies"), whose work examined and predicted various options for global development.

Realizing the importance of solving global environmental problems, the United Nations created a special unit in 1972, the United Nations Environment Program, which has been

addressing global environmental issues for more than 50 years (UNEP, 2025). In addition, several international non-governmental environmental organizations regulate environmental issues quite effectively: World Wildlife Fund (WWF); International Union for Conservation of Nature (IUCN); World Society for the Protection of Animals (WSPA); Greenpeace; and International Green Cross.

Ukrainian research on the environmental challenges facing modern society also encompasses a range of foundational scientific works by prominent national scholars, including Deineko *et al.* (2017), Kaletnik (2020), Karpinska (2018), Melnyk (2016), Prutska and Khodakivska (2021), Sabluk (2017), among others. They assessed the categories of greening and analyzed environmental issues, formed the main theoretical and methodological approaches to the implementation of tasks and the formation of an effective mechanism for state regulation of the greening of the national economy. At the same time, it should be emphasized that the war, with its challenges, poses new problems in the development of Ukraine, radically transforming the pre-war postulates of environmental science. Ukrainian scientists, together with their foreign colleagues, are making significant efforts to identify opportunities for assessing and developing ways to overcome the environmental losses that occurred during the war, but their research requires constant expansion and supplementation (Bessonov, 2022; Djatkov, 2024; Lebed *et al.*, 2024; Lopatynskyi *et al.*, 2023).

Meanwhile, environmental problems are virtually absent from the government's institutional and organizational architecture of postwar rebuilding. For example, the Ministry of Environment lacks a deputy minister for post-war rebuilding, and the DREAM system needs further refinement to appropriately represent the environmental components of reconstruction. DREAM is an electronic government platform that collects, organizes, and distributes open data in real time across all stages of restoration projects. It was originally presented at the Ukraine Recovery Conference in London, and beta testing for the upgraded features began in November 2023. In November 2023, the platform made its data available via API, making it much easier for the public to use.

The experience of other countries in addressing war-related environmental losses should be taken into account and adapted to national realities. However, given the current specifics of the functioning of the Ukrainian state, it is necessary to constantly reassess environmental realities and identify new tasks of environmental regulation. It is important to develop new scientific and practical concepts, appropriate to the national specifics and the consequences of the war, to find ways to restore the natural balance and solve environmental problems in the country.

# Methodology

The study focuses on aspects of the impact of military operations in Ukraine on the state of the environment. Particular attention is paid to the need to improve the sectoral legal framework, integrate international standards, and identify priorities for environmentally sustainable development amid the challenges of war.

# **Data Collection and Sources**

The article is based on a toolkit of content analysis of expert publications, scientific articles, and statistical information. First of all, we selected relevant primary sources from publications indexed in leading databases (Scopus, Web of Science, JSTOR, ScienceDirect). The criteria for including and excluding publications were the spatial and temporal indicators and the level of information reliability. The works taken into account were mostly published in the time interval between 2020 and 2025. The keywords used for the search were "Ecology; Biodiversity; Natural resources; Environment; Pollution, Post-war environmental recovery, Damage to environment during war", "Post-war green reconstruction".

# Analytical Framework and Methods

The research employed a wide range of scientific methods. Dialectical cognition was applied in the study and theoretical generalization of scientific postulates related to environmental issues. System analysis was used to assess the development of environmental concepts within societal progress. Comparative analysis facilitated the examination of environmental indicators during both the pre-war and wartime periods in Ukraine. Statistical analysis was employed to interpret data on the country's environmental conditions. Finally, abstract and logical analysis supported the formulation of conclusions based on the synthesized information. The results and conclusions were formed using the method of deduction and scientific abstraction. This made it possible to mentally move away from standard indicators of environmental impact and consider the phenomenon under study in the context of wartime, which requires appropriate adaptability.

Another method applied was the case-study method, which allowed considering approaches and best practices of post-war reconstruction in other countries. Assessing environmental damage was carried out based on a qualitative paradigm – statistical data were taken mostly from secondary sources.

## Results

The twenty-first century has become a period of accumulation of a significant number of problems in the development of society that have reached global proportions. The ecological crisis that has arisen as a result of irresponsible anthropogenic activity is becoming one of the main modern threats to the survival of humanity. The Ukrainian state is also characterized by a high level of environmental tension throughout its territory. In the pre-war period, the problems of irrational use of natural resources and environmental pollution had been accumulating for a very long time. The problems of environmental protection that arose from industrialization. The environmental protection challenges that emerged during the Soviet period, due to unchecked industrialization and the chemicalization of agriculture without adherence to environmental standards, were further intensified by the Chernobyl disaster. These problems have been critically aggravated in the period of national independence by the irresponsible exploitation of natural resources and the absence of an effective system of environmental safeguards to ensure the quality of social relations (Smirnova et al., 2024). According to the national report of the Ministry of Environmental Protection and Natural Resources of Ukraine, as of 2021, the total amount of air pollutant emissions in Ukraine amounted to 1546.8 thousand tons (37.4 kg per person), and 4684.6 million cubic meters of wastewater were discharged into surface waters. Land use also had several problems with soil quality: about a third of Ukraine's arable land was characterized by a significant degree of erosion, 40% of the land was over-compacted, and 20% had unregulated acidity levels. In addition, almost 70% of the arable land was in a state of moisture deficit, overuse of chemicals, and lack of natural nutrient balance (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021).

The war has become a factor in further deepening the environmental crisis in Ukrainian society. Full-scale hostilities have virtually eliminated all projects aimed at promoting the formation of Ukraine's green economy. They caused huge destruction, led to large-scale loss of life and economic losses, and critically affected the environmental situation in the country.

The environmental damage in Ukraine has been enormous since the start of the full-scale Russian invasion in February 2022. In a single year, more than 2,364 cases of environmental damage have been reported, with costs totalling an astounding 1.9 trillion Ukrainian hryvnias (about \$52.4 billion). Furthermore, the effects on the environment go beyond the areas where the conflict is taking place. Ukraine, which makes up less than 6% of the continent's land area, is home to about 35% of Europe's biodiversity, which is seriously threatened. Approximately 600 animal species and 750 plant and fungal species—many of which are rare and on the Red List of vulnerable species—are in danger of becoming extinct as a result of the battle. For example, thousands of dead dolphins have been discovered in Bulgaria, Romania, and Turkey in addition to Ukraine (Kasyanchuk and Kostenko, 2024).

The war has a negative impact on Ukraine's forests and protected regions. While approximately 500,000 hectares of forests and 21 forestry operations are still occupied and pose ongoing threats, over 2.4 million hectares of wood and 24 forest enterprises have been released from occupancy and need to be restored. The conflict has impacted over 20% of Ukraine's environmental reserves, putting 812 protected areas at risk and causing damage to around 1 million hectares of conserved land. Eight reserves, two biosphere reserves, and ten national parks are still occupied (Kasyanchuk and Kostenko, 2024). Experts claim that because of fighting, fires, infrastructure devastation, and other direct and indirect repercussions, the war's influence on the environment is growing each month. Numerous uncontrolled leaks of SF6 (sulfur hexafluoride), a greenhouse gas more powerful than carbon dioxide, methane, and nitric oxide, have resulted from extensive attacks on the Ukrainian electrical infrastructure (Kasyanchuk and Kostenko, 2024).

One of the most significant forms of damage resulting from the war in Ukraine is the large-scale destruction of natural biodiversity, including both flora and fauna. The estimated total loss of flora alone has already exceeded UAH 150.09 billion, with damage to wild plant habitats reported across more than 20,631 hectares. The destruction of forests has become one of the most significant contributors to air pollution in Ukraine. As of early 2025, after three years of ongoing hostilities, air emissions have totalled more than 129.584 million tons of pollutants. These include approximately 430 thousand tons

of carbon monoxide, 700 thousand tons of various types of particulate matter (dust), and up to 40 thousand tons of specific non-methane volatile organic compounds. The air also contains a significant amount of heavy metals, chemical elements, and organic harmful substances. As of February 1, 2025, the Ministry of Environmental Protection and Natural Resources recorded 1622 cases of air pollution, with more than 72.6 million tons of military waste emitted into the atmosphere. In total, losses from air pollution amounted to UAH 776.78 billion (EcoZagroza, 2025). Based on the analysis of the structure of atmospheric pollution shown in Fig. 1, it is worth noting that forest fires have become the main factor of air pollution, with losses from them accounting for 85% of the damage structure. The total amount of air pollution directly due to air emissions from forest fires reached 61.8 million tons (Figure 1).



Figure 1: Military air emissions in Ukraine as of February 1, 2025, million tons [Source: Ministry of Environmental Protection and Natural Resources (EcoZagroza, 2025; Filho *et al.*, 2024)]

Forest fires have become widespread due to the war, especially in the areas of hostilities. As of February 2025, losses caused by forest fires are estimated by the State Environmental Inspectorate at over UAH 736.64 billion. The total area of burned forests and other plantations is more than 15015 hectares (EcoZagroza, 2025). Forests are a resource of extremely long regeneration time, especially in the presence of valuable long-growing tree species, and they are also a special, often unique, form of

biogeocenosis. This complex natural system is formed under specific conditions of interaction between flora and fauna and may not be restored to its original state at all.

Given that the estimated cost of destroyed and damaged trees and plants is UAH 561.90 billion, and their number is approximately more than 27,686,009, we can confidently predict significant losses of natural diversity. It is obvious that in the burned forests, under the condition of self-regeneration, there will be a simplification of the plant and animal structure, and vulgarization of the biota will be observed. If there is no targeted intervention in the restoration of phytocoenoses (and targeted intervention is a long and expensive process, especially for valuable and rare plant species), it will become almost impossible.

The loss of wildlife, especially rare species, is also catastrophic, with the total damage from the destruction of wildlife currently amounting to about UAH 162.92 million, with over 75,110 wild animals killed. As of August 2024, more than 200 rare animals were destroyed and stolen in the Askania Nova reserve alone, 7109 hectares of unique steppe burned down, and the total damage from military aggression amounted to 62.4 million UAH (Askania-Nova: war and fires, 2025). It should be borne in mind that the loss of fauna occurs not only due to its destruction, but also due to the migration of most fauna representatives from dangerous areas, with low chances of their return to their previous habitats in the future. The restoration of fauna in Ukraine is a highly complex and fragile process, taking place under conditions of chemical pollution, food scarcity caused by widespread fires, and the persistent threat of landmines. These factors have forced many animal species, particularly rare and endangered ones, to either migrate from hazardous areas or face extinction. The loss of biodiversity across Ukraine's ecosystems is alarmingly high and continues to escalate with each passing day of the war. As a result, the likelihood of natural recovery and the return to ecological equilibrium is diminishing rapidly.

The assessment of changes in the state of Ukraine's water resources as a result of hostilities also indicates significant environmental damage. In total, according to the Ministry of Environmental Protection and Natural Resources, 216 cases of direct damage to water bodies in Ukraine caused by military operations were registered, and the total cost of losses is estimated at UAH 93.07 billion. In addition, the losses caused by violation of the rules for the use of water resources also include unauthorized water withdrawn and used, the damage from which is estimated at UAH 26.77 billion, with the estimated volume of such water being 20,937,563,991 m<sup>3</sup>.

Based on our analysis in Table 1, we can state that pollution of freshwater and marine objects is becoming the most significant factor in causing environmental damage to water resources, accounting for 64.6% and 23.6% of the recorded losses, respectively. It is worth emphasizing that it is impossible to accurately assess the damage to Ukraine's water resources, as some of them are located in the areas of hostilities and occupation. A significant amount of shells, oil waste, military equipment, as well as various types of chemicals, falling into rivers and water bodies, will decompose in them for a long time, poisoning the environment and endangering people, flora and fauna. The corpses of people and animals drowned in water bodies pose a particular danger in terms of biological contamination. Thus, a significant amount of toxic substances and waste

arising from the hostilities accumulates in the water, which leads to its poisoning and makes it unfit for consumption. Given that up to 80% of Ukraine's water supply is based on surface water, the pollution of this resource poses a threat to the consumption of quality water by the population and the supply of water to industrial and agricultural production.

Table 1: Pollution of Ukraine's water resources as a result of the war as of February 1, 2025

Types of losses	The cost of damage		The amount of pollution		
	Billions of hryvnias	In % of total	Thousands of tons	In % of total	
Pollution of water bodies	49,28	64,59	23,3	18,39	
Pollution of water bodies	8,99	11,78	37,3	29,44	
Pollution of marine waters	18,03	23,63	66,08	52,16	
Total	76,3	100,00	126,68	100,00	

*Source*: EcoZagroza, 2025; Filho et al., 2024; Ministry of Environmental Protection and Natural Resources, 2021; Nazir *et al.*, 2025

The situation with pollution in the Black Sea is also complicated, with the share of emissions in the Black Sea amounting to 52.16%. The hostilities resulted in significant water pollution with oil and oil products throughout the sea and along the coast. One of the largest oil spills that occurred on December 15, 2024, near the Kerch Strait was a spill from two Russian tankers (according to various estimates, from 2,400 to 8,500 tons of fuel oil). Such pollution poses a threat to the entire Black Sea ecosystem, leading to massive death of fish, birds, and animals, and the period for eliminating its consequences can be more than 12 years (Symonova, 2024). The fighting has made the deterioration of the marine ecology, a long-standing issue in this part of Europe, worse. The conflict is also generating new threats that will persist for years to come. Cleaning up the Black Sea should be a major priority for the EU and the surrounding countries. Furthermore, the Ukrainian Danube port cities of Izmail and Reni have been continuously bombarded by Russian missiles and drones since July 2023, which may have an adverse effect on the environment for Romania and other Danube-bordering European nations.

The consequences of one of the largest environmental crimes in Russia, the explosion of the Kakhovka hydroelectric power plant, which is estimated at UAH 146.4 billion in environmental damage, should be considered as a separate line of damage to water resources. The level of water reduction is 14.395 cubic kilometres, which radically changes the level of humidity and access to water resources in a large area of southern Ukraine. A significant number of people and agricultural production have experienced water shortages and a decline in water quality. The total area of forests that were flooded is 63,447 hectares. At the same time, the consequences of the destruction of the Kakhovka HPP have become a vivid example of nature's ability to regenerate itself, as in such a short period the ecosystem that was characteristic of this area before the construction of the reservoir was re-established in the form of Dnipro floodplains with large willow forests. Despite the processes of self-restoration of the territories that were under the waters of the Kakhovka Sea, the loss of so many water reserves in general has

a negative impact on the life of the southern region of Ukraine and requires the search for new ways to supply water to the population and production (Afonina, 2024; EcoZagroza, 2025).

The ongoing war in Ukraine has also caused significant damage to the country's land resources, resulting in loss of fertility, destruction, and waste pollution. The hostilities have rendered a significant area of land unsuitable for economic use. As of the end of 2024, an estimated 186,000 square kilometres of land were damaged and contaminated, which is 31% of the total area of the entire territory of Ukraine. Of the damaged land, more than 30,000 square kilometres have a level of destruction and damage that exceeds 75% of their pre-war natural fertility. Most of the soil loss is observed in the areas where direct hostilities are taking place, namely in the East and South of Ukraine, but also in other regions. Soil fertility losses are caused by mining, shelling and bombing, explosions, contamination of land with war waste, construction of fortifications, fires in forests, steppe zones, fields and settlements (KSE, 2024).

In addition, soil contamination due to contamination with corpses should be taken into account, which carries the potential risk of spreading several biological hazards. The Ministry of Environmental Protection and Natural Resources estimates the total value of losses from land damage at UAH 1.21 trillion as of the beginning of 2025. The number of legally recorded cases of damage to land caused by hostilities reached 2,912 (EcoZagroza, 2025). It is worth emphasizing that the value of soil losses in terms of price and quantity is constantly increasing, and the ongoing hostilities cover more and more territories, increasing the number of lands that lose their fertility potential.

A negative factor affecting soils during the war was the mining of territories, which led to significant risks in the economic use of land and to its contamination with toxic substances. As of the beginning of 2025, according to the Ministry of Defence of Ukraine, about 30% of Ukraine's territory is contaminated with explosives, unexploded bombs and shells, and mines. Potentially dangerous and mined areas cover more than 139,000 km2 of land, as well as more than 14,000 km<sup>2</sup> of water. During the war, a total of 59040 hectares of land were identified as hazardous areas. From an economic point of view, annual losses due to the mining of agricultural land amount to more than \$11.2 billion (EcoZagroza, 2025).

The overall assessment due to the creation of a unified Register of Damaged and Contaminated Areas in Ukraine is still in its infancy, but 2291 sites of contaminated land have already been identified, with a total area of 302.9 km<sup>2</sup> (Mine Action Centre, 2025). Thus, according to the assessment, it can be stated that the war resulted in significant soil damage. It is both physical, as a result of hostilities, and burning due to fires, chemical intoxication of soils, and biological pollution. All of this together leads to increased risks of total ecosystem change in the affected areas.

The environmental problems that have arisen as a result of the hostilities in Ukraine are very acute, and there is no way to begin to address them systematically and comprehensively because of the ongoing war. However, despite this, the Cabinet of Ministers of Ukraine, scientists, and international organizations are trying to at least partially eliminate environmental threats and identify ways to solve the problems that have arisen (Resolution of the Cabinet of Ministers of Ukraine<sup>1</sup>, 2023). The issue of restoring the environment is included in several special projects with the general title "Restoring a Clean and Protected Environment", the estimated cost of which is about \$20 billion (Post-war Recovery Plan of Ukraine, 2025).

# Discussion

Restoration of Ukraine's ecological system requires a significant amount of work of a legal, political, economic, organizational, environmental and social nature. The processes of restoring the natural and climatic balance of Ukraine must also meet international climate goals, primarily by the norms of the European Green Deal (Order of the Ministry of Environment<sup>2</sup>, 2023). It is worth emphasizing that Ukraine can comprehensively address the problems of environmental restoration only in peace. The restoration and changed conditions for the use of natural resources should be aimed not only at eliminating the damage caused by the war, but also at overcoming the general problems of destruction and pollution that have accumulated since the pre-war period due to irresponsible use of the environment. Among the important consequences of the violation and damage to Ukraine's natural environment, we can expect climate change as a result of changes in the terrain, including after the explosion of the Kakhovka gas storage facility. The main consequences of the war for Ukraine's environment are desertification and the problem of access to water resources; pollution of water resources and their unsuitability for use; changes in flora and fauna, loss of forest plantations, reduction of biodiversity and survival of the most resistant species; loss of soil fertility, pollution and burning of the fertile layer as a result of hostilities; the emergence of a group of dangerous territories with land contaminated with explosives, biologically pathogenic and chemical substances.

Several options for restoring the ecological balance can be identified based on the experience of countries that have experienced war. For example, in Sudan, restoration was carried out with the use of targeted investments based on UNEP recommendations for the medium-term period of corrective actions to ensure environmental protection (UNEP, 2007). For Congo, environmental restoration was more focused on the ability of nature itself to recover with targeted adjustments (UNEP, 2011). So far, we can only assess the damage and try to eliminate it in conditionally safe areas. In the future, based on the international Principles of Ecological Restoration for Ukraine, various variations of involvement of territorial communities, national and international scientists, politicians, landowners and land managers, and international funds in the processes of eliminating the damage that has been caused to the environment are envisaged (Gann et al., 2019). "Green recovery" is defined as one of the main vectors of Ukraine's post-war development, when the economy is being renewed while simultaneously greening it. The UNDP considers an environmentally oriented approach to the reconstruction of Ukraine, whereby recovery relies on the recycling and ecological use of war waste (United Nations Development Programme, 2023). If no restorative measures are taken by human

Resolution of the Cabinet of Ministers of Ukraine of 7 July 2023 No. 610-p "On approval of the Concept of the State Targeted Environmental Program for Environmental Monitoring". (2023). Available online at: https://ips.ligazakon.net/document/kr230610?an=1 [Accessed on 16 March 2025]

Order of the Ministry of Environment of 03.06.2023 No. 386 "Methodological recommendations for assessing risks and vulnerability of socio-economic sectors and natural components to climate change". (2023). Available online at: https://mepr.gov.ua/wpcontent/uploads/2023/06/386nd1.pdf [Accessed on 16 March 2025]

society, it is obvious that nature itself can recover from the war. Such recovery will be long-lasting, and changes in nature are difficult to predict. In cases where the public, government, and non-governmental organizations make efforts to restore the environment, we can expect results that correspond to the vectors of their efforts. So, with or without the help of people, nature will recover, adapt, and restore. But whether there will be a place for people in this nature is a very ambiguous question.

Among possible and expedient strategies of post-war environmental restoration, one should especially mention the strategy of green recovery, in particular based on local priority initiatives. The example, which can serve as a benchmark, is, in particular, the Green Mosul initiative, which was launched by the Mosul Eye Association in 2021 and leaves a legacy that is still visible today. It refers to the greening program, which aimed to repopulate Mosul with green space following the immense devastation caused by the battle. Green Mosul ran from March 2022 to March 2023, and during that time, 9,000 trees were planted in Mosul and the surrounding Nineveh province. When the campaign began, agreements were struck with the local government and colleges, with one of the requirements requiring them to plant trees each year. Green Mosul has already formally ceased, although the University of Mosul and the Technical University of Mosul continue to plant trees every year, and the local government has also set aside a portion of its budget for tree planting each year (ISCR, 2024).

A green recovery is about repairing the damage and putting Ukraine on a new path toward environmental and social sustainability. One of the priority SDGs should be, in our opinion, SDG11 - "Sustainable cities and communities", since it would enable green development and social cohesion simultaneously. In Iraq, such a project covers nine governorates (Salah al-Din, Anbar, Ninewa, Basra, Dohuk, Erbil, Sulaymaniyah, Missan, and Thi Qar). Building on the achievements and momentum of the Local Area Development Program (LADP II) 2015-2018, which aimed to strengthen institutional capacity for community-based strategic and sectoral planning in 12 governorates across Iraq. This initiative is the next stage in bridging the gap between local government, civic society, and local communities. Using a unique bottom-up strategy to ensure local ownership, UNDP will strengthen the Iraqi government's capacity to sustainably scale up local pilot initiatives at the national level. The project's overarching purpose is to contribute to Iraq's stability and socioeconomic development by implementing local priority actions addressing important governance, environmental, economic, and social concerns. It entails improving living conditions in conflict-affected communities so that people may return to their homes. Green initiatives involving adolescents and women are key to the activities carried out under the program Supporting Iraq's Recovery and Stability through Local Development.

Probably the brightest 21<sup>st</sup>-century example of environmental damage due to war conflict is Syria. The protracted conflict in Syria has seriously worsened the country's environmental circumstances, negatively impacted people's quality of life, raised carbon emissions, and resulted in high pollution levels. One of the most significant issues facing the nation is pollution, which permeates every aspect of the environment—from the air to the water to the land. According to the "IQAir" index, which rates air quality, Syria was ranked 18th out of the world's most polluted nations in 2019. The country's annual average concentrations of fine particulate matter (PM2.5) reached 32.2, which is three times the average concentration advised by the World Health Organization (Badawi, 2025). There was a 13-year struggle on the property. It was thus turned into a desolate and toxic area with soil holding heavy metals, including arsenic, lead, and mercury, as well as fuels, solvents, and active ingredients from explosives and weapons. Many farmers have been forced to irrigate their crops with contaminated wastewater due to droughts and water shortages. Naturally, agricultural losses have gotten worse as a result of pollution and land degradation, which have also exacerbated soil erosion and the loss of productive land (Badawi, 2025). Since "green recovery" is a component of prosperity and development, sustainability is used as a 'compass' in post-war reconstruction to map out environmental changes and address widespread pollution. This includes implementing sound planning, environmentally friendly architecture, solid waste management, and looking for safe ways to secure clean energy, such as hydroelectric and renewable energy, encouraging flexible agricultural practices, and utilizing technology to map environmental changes and address widespread pollution. It is believed that sustainable design allows planners to reduce the use of new construction supplies, be cautious while using present building materials, and recycle building materials from demolished structures. One viable option is to use green building codes such as the LGGE Energy Efficiency Code in Buildings, which is a global project funded by the Global Environmental Facility and implemented by the UN Development Program to reduce CO<sub>2</sub> emissions through the implementation of thermal and energyefficient building codes for new construction. Using recycled construction materials instead of new materials may be another efficient strategy to conserve natural resources and minimize the amount of energy available, in addition to providing significant economic benefits (Gaafar, 2021). Rubble reuse has also been demonstrated to be effective in lowering trash disposal and pollution associated with demolition (Gaafar, 2021). The viability of the reconstruction process and the preservation of Syria's architectural character can be enhanced by the preservation, classification, and reuse of recovered building materials (stones, timber, and metal) for the construction of new buildings and components, including facilities for a new solar energy system, as well as for the renovation of existing structures.

Another strategy that should be considered within models of environmental post-war reconstruction in Ukraine is developing Green Agenda. In contrast to local priorities, this should be a nation-scale strategic document, not of declarative nature, but containing detailed plan, roadmap, and expected results. Here, Western Balkans experience may be modified and implemented. The Green Agenda for Western Balkans is built on four flagships: 1) Environment and Climate; 2) Clean Energy; 3) Sustainable Transportation; and 4) Private Sector Development (Djatkov, 2024).

Crucially, establishing local capacity to conduct such assessments is necessary to ascertain the extent of the damage. This might be achieved through cooperative training with Ukrainian experts, labs, and research institutions. By providing training on assessment methods and techniques, local specialists can better assess and track the environmental harm caused by the conflict. In the end, what is required is a knowledgeable, adaptable, and multidimensional strategy that combines long-term environmental initiatives with immediate environmental emergency requirements.

# Conclusions

In the recent history of mankind, the war in Ukraine has become the most vivid example of huge environmental damage that the use of modern weapons and methods of warfare can lead to. The destruction and damage to soil, water resources, the atmosphere, and the destruction of plant and animal life should be considered crimes of global proportions and be evaluated in frames of international law, with involvement of international legal mechanisms such as Rome Statute. The consequences of ecosystem disruption will be felt for many years to come, not only in Ukraine but also within the European region. Restoring and returning to the ecological balance of Ukraine's natural environment requires significant costs. According to a joint assessment by experts from the Government of Ukraine, representatives of the World Bank Group, the European Commission and the United Nations, which is presented in the Rapid Assessment of Damage and Recovery Needs for the end of 2024, the cost of all reconstruction and recovery in Ukraine already amounts to 524 billion US dollars (or 506 billion euros), with the environmental component alone costing more than 13 billion US dollars (World Bank, 2024). Recovery processes will be long-term, with no guaranteed return to the pre-war state. Nature can recover on its own, but it is difficult to predict how long it will take. However, there is a chance that the abandoned farms and villages already constitute the greatest precedent for the spread of alien species in history. Furthermore, the overall area covered by invading species already much outstrips the area covered by steppe ecosystems in the wild. The main issue and maybe a roadblock for professional biologists and land managers in the upcoming decades will be preparing for scenarios that combine the creation of new ecosystems with cohabitation with humans for land regions undergoing spontaneous vegetation recovery. Furthermore, it is now unknown how long Ukraine will be partially occupied, much alone how long the demining procedure will take. The Ukrainian Cabinet of Ministers has made early estimations that demining will take over 70 years. Therefore, it is reasonable to assume that the final post-war cleanup efforts would occur in places where a 70-year-old forest is already developing and mines are buried well beneath tree roots. Nevertheless, an array of cases of post-war environmental reconstruction in the end of 20th and in 21st century exists, and the task is to properly investigate and analyze them, extract and adapt best practices and systematize potential challenges.

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Contribution	Author 1	Author 2	Author 3	Author A	Author 5
Contribution	Aumor 1	Aumor 2	Aunor 5	Aumor 4	Aumor J
Conceived and designed the research or	Yes	Yes	Yes	Yes	Yes
analysis					
Collected the data	Yes	Yes	No	No	No
Contributed to data analysis &	No	Yes	No	Yes	No
interpretation					
Wrote the article/paper	Yes	Yes	Yes	Yes	Yes
Critical revision of the article/paper	Yes	No	No	Yes	Yes
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