

A cura di
NICOLA GULLO

CLIMATE JUSTICE PERSPECTIVES IN THE AGE OF GLOBAL CONFLICT



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ENVIRONMENTAL ISSUES IN UKRAINE: CONSEQUENCES OF WAR

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Abstract. This article examines the environmental consequences of the war in Ukraine and their impacts on the environment, climate, biodiversity, and the prospects for sustainable post-war recovery. The study aims to identify the main forms of environmental degradation caused by the military aggression of the Russian Federation and to highlight the key challenges requiring long-term restoration measures. The research is based on the analysis of official statistical data, international analytical reports, state information resources, and documented evidence of war-related environmental damage. The paper analyses greenhouse gas emissions resulting from military activities, the destruction of critical infrastructure, large-scale landscape fires, and reconstruction efforts. The findings show that cumulative war-related greenhouse gas emissions have reached a level comparable to the annual emissions of several European countries, demonstrating the significant contribution of armed conflict to climate change. Particular attention is given to landmine contamination, soil degradation, the reduction of safe agricultural land, and the impacts of the war on Ukraine's protected areas and biodiversity. The study also examines documented environmental crimes and emphasizes their importance for environmental damage assessment and international accountability. It is concluded that Ukraine's post-war recovery should combine infrastructure reconstruction with ecosystem restoration, humanitarian demining, biodiversity conservation, and the integration of sustainable development and climate justice principles into environmental policy. The findings may support the development of environmental recovery strategies and improve approaches to assessing war-related environmental damage.

Keywords: war-related environmental damage, environmental war crimes, greenhouse gas emissions, landmine contamination, biodiversity conservation, climate justice, Ukraine.

Riassunto. L'articolo analizza le conseguenze ambientali della guerra in Ucraina e i loro effetti sull'ambiente, sul clima, sulla biodiversità e sulle prospettive di una ricostruzione sostenibile nel periodo postbellico. L'obiettivo dello studio è individuare le principali forme di degrado ambientale causate dall'aggressione militare della Federazione Russa e mettere in evidenza le principali sfide che richiedono interventi di ripristino a lungo termine. La ricerca si basa sull'analisi di dati

statistici ufficiali, rapporti analitici internazionali, risorse informative istituzionali e documentazione relativa ai danni ambientali causati dalla guerra. Il contributo esamina le emissioni di gas a effetto serra derivanti dalle operazioni militari, dalla distruzione delle infrastrutture critiche, dagli incendi di vasta scala e dalle attività di ricostruzione. I risultati dimostrano che le emissioni cumulative associate alla guerra hanno raggiunto un livello paragonabile alle emissioni annuali di diversi Paesi europei, evidenziando il significativo contributo dei conflitti armati ai cambiamenti climatici. Particolare attenzione è dedicata alla contaminazione del territorio da mine terrestri, al degrado del suolo, alla riduzione delle superfici agricole sicure e agli effetti della guerra sulle aree protette e sulla conservazione della biodiversità in Ucraina. Lo studio esamina inoltre i crimini ambientali documentati, evidenziandone l'importanza ai fini della valutazione dei danni ambientali e della responsabilità internazionale. Si conclude che la ricostruzione postbellica dell'Ucraina dovrebbe coniugare il ripristino delle infrastrutture con il recupero degli ecosistemi, lo sminamento umanitario, la conservazione della biodiversità e l'integrazione dei principi dello sviluppo sostenibile e della giustizia climatica nelle politiche ambientali. I risultati dello studio possono contribuire allo sviluppo di strategie per il recupero ambientale e al miglioramento degli approcci alla valutazione dei danni ambientali causati dalla guerra.

Parole chiave: danni ambientali causati dalla guerra, crimini ambientali di guerra, emissioni di gas a effetto serra, contaminazione da mine terrestri, conservazione della biodiversità, giustizia climatica, Ucraina.

1. Introduction

The full-scale war in Ukraine has become not only a humanitarian and security crisis but also one of the most significant environmental challenges in Europe in recent decades. Military operations have caused widespread damage to natural ecosystems, air quality, water resources, soils, forests, and biodiversity. Unlike many other environmental disasters, the consequences of armed conflict are long-lasting and affect both ecological processes and socio-economic development. In addition to the direct destruction of ecosystems, the war has intensified greenhouse gas emissions, increased the risk of industrial pollution, and created large-scale contamination by landmines and explosive remnants of war.

Environmental degradation caused by the war extends far beyond the areas of active hostilities. Damage to protected areas, disruption of ecosystem services, pollution of rivers and soils, and the destruction of critical infrastructure have created complex environmental challenges that will

require decades of recovery. These impacts also have transboundary implications, affecting regional climate policy, biodiversity conservation, and international environmental security.

Although the environmental consequences of armed conflicts have increasingly attracted international scholarly and policy attention, comprehensive assessments of war-related environmental damage remain limited due to the complexity of documenting ongoing hostilities and the multi-dimensional nature of ecological impacts. In the case of Ukraine, environmental degradation encompasses climate change, land contamination, biodiversity loss, damage to protected areas, and large-scale industrial pollution, all of which require an integrated analytical approach. Understanding these interconnected impacts is essential for developing evidence-based environmental policies, supporting international accountability mechanisms, and ensuring that post-war reconstruction is guided by the principles of sustainable development and climate justice.

Against this background, the assessment and documentation of environmental damage are essential for understanding the scale of ecological losses, supporting international accountability, and developing effective strategies for sustainable recovery. Therefore, the purpose of this study is to analyse the major environmental consequences of the war in Ukraine, focusing on climate impacts, land contamination, biodiversity loss, environmental crimes, and the destruction of natural ecosystems.

2. Climate Impact of the War

Russia's full-scale invasion of Ukraine has resulted not only in the largest humanitarian and security crisis in Europe in recent decades but also in unprecedented environmental consequences. One of the most significant manifestations of this impact is the substantial increase in greenhouse gas (GHG) emissions directly associated with military operations, the destruction of infrastructure, large-scale wildfires, and subsequent reconstruction activities.

According to expert estimates [1, p. 3], GHG emissions generated during the fourth year of the full-scale war alone amounted to approximately 75 million tonnes of CO₂-equivalent. Since 24 February 2022, cumulative war-related emissions have reached 311.4 million tonnes of CO₂-

equivalent (Figure 1).



Figure 1. Cumulative Greenhouse Gas Emissions Caused by the War in Ukraine (24 February 2022-23 February 2026), MtCO₂-eq Source: Compiled by the author based on [1, p. 3].

For comparison, annual GHG emissions in 2024 amounted to 371.2 million tonnes of CO₂-equivalent in Italy, 378.1 million tonnes of CO₂-equivalent in France, and 348.0 million tonnes of CO₂-equivalent in Poland [2]. These figures indicate that the cumulative climate footprint of the war in Ukraine is already comparable to the annual greenhouse gas emissions of major European Union economies. This highlights the global climate consequences of the conflict and its implications for international climate mitigation efforts.

Emissions increased across virtually all impact categories (Table 1). Direct military activities remained the dominant source of greenhouse gas emissions, while reconstruction activities and landscape fires represented the second and third largest contributors, respectively. The results suggest that both the immediate effects of military operations and the indirect consequences of infrastructure damage and ecosystem degradation play a significant role in shaping the overall climate footprint of the war.

Table 1. Greenhouse Gas Emissions After Four Years of the War

Impact category	Emissions after 48 months (MtCO ₂ -eq)	Share of total emissions (%)
Warfare	114.1	37
Landscape fires	70.3	23
Energy infrastructure	18.6	6
Refugees	5.3	2
Civil aviation	29.8	9
Reconstruction	73.3	23

Total 311.4 100

Source: Compiled by the author based on [1, p. 4].

Landscape fires became one of the fastest-growing sources of greenhouse gas emissions during the fourth year of the war. Their increasing contribution can be attributed to the combined effects of military activities and adverse meteorological conditions, including prolonged droughts and elevated air temperatures. Under these conditions, fires ignited by shelling and explosions frequently developed into large-scale wildfires. Fire suppression efforts were further hindered by ongoing hostilities and the presence of mine-contaminated areas, resulting in prolonged burning periods and higher greenhouse gas emissions. These findings illustrate the interaction between armed conflict and climate change, whereby military activities increase wildfire occurrence, while climate-related extreme weather conditions intensify fire severity and spatial extent.

Greenhouse gas emissions associated with reconstruction activities also increased substantially. A significant share of these emissions resulted from the restoration of Ukraine's energy infrastructure following extensive damage caused by missile and drone attacks during the winter of 2025-2026. Reconstruction requires the production of carbon-intensive construction materials, their transportation, and the operation of heavy machinery, all of which contribute to additional greenhouse gas emissions.

Beyond direct military operations and reconstruction, the war generated greenhouse gas emissions through multiple indirect pathways, including fuel combustion by military vehicles, the destruction of industrial facilities, fossil fuel leakage, and changes in civil aviation and maritime transport routes. Collectively, these findings demonstrate that armed conflicts constitute a substantial, yet frequently underestimated, source of anthropogenic greenhouse gas emissions. Their inclusion in climate accounting frameworks is essential for a comprehensive assessment of conflict-related environmental impacts.

The growing recognition of the climate impacts of armed conflicts has stimulated the development of international mechanisms for environmental accountability. During COP30 [3], Ukraine announced its intention to seek compensation from the Russian Federation for climate-related damage resulting from military aggression. The planned submission under the "Environmental Damage" category of the Register of Damage for

Ukraine represents an important step toward integrating environmental losses into international compensation mechanisms. Based on a social cost of carbon of USD 185 per tonne of CO₂-equivalent, the estimated climate-related damage exceeds USD 57 billion [1, p. 3]. The evidence demonstrates the substantial economic costs of conflict-induced greenhouse gas emissions and underscores the importance of integrating climate considerations into post-war recovery strategies and international environmental governance.

3. Landmine Contamination and Soil Degradation

While greenhouse gas emissions are among the most significant climate-related consequences of the war, they represent only one dimension of its environmental impact. Another critical challenge is the widespread contamination of land by landmines and other explosive remnants of war, which poses long-term risks to ecosystems, agricultural production, and sustainable land management. As shown in Figure 2, potentially mine-contaminated areas cover a substantial part of Ukraine's territory, creating long-term environmental, economic, and humanitarian challenges.

Landmine contamination has profound environmental consequences that extend well beyond the immediate threat to human life. The presence of explosive remnants of war restricts access to forests, agricultural land, wetlands, and protected areas, limiting ecosystem management and delaying environmental restoration. In addition, explosions and the long-term presence of munitions contribute to soil degradation through physical disruption, contamination by heavy metals and explosive residues, and the destruction of soil biological processes. These impacts reduce soil fertility, alter microbial communities, and impair the capacity of ecosystems to recover naturally.

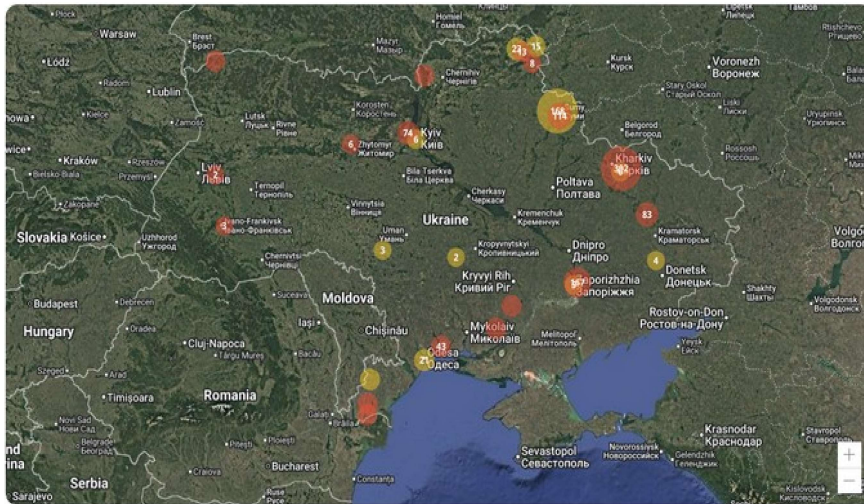


Figure 2. Map of Potentially Mine-Contaminated Areas in Ukraine *Source: State Emergency Service of Ukraine (SESU), Interactive Mine Action Map [4].*

The agricultural sector has been among the most severely affected. According to recent estimates, more than 5 million hectares of agricultural land remain unsafe or unsuitable for cultivation due to landmine contamination and unexploded ordnance. Moreover, approximately 139,300 km² of Ukraine's territory is considered potentially hazardous as a result of mine contamination and military activities, making Ukraine one of the most heavily mine-contaminated countries in the world. Although more than 49,000 km² of land have been cleared since February 2022 and over 21,000 km² were returned to productive agricultural use in 2025, vast areas of land remain unsafe for cultivation [5]. In areas directly affected by shelling and explosions, soil contamination by heavy metals, fuel residues, and explosive compounds poses long-term risks to agricultural productivity and ecosystem recovery.

The loss of productive farmland not only threatens national food security but also reduces agricultural exports and undermines rural economic development. Furthermore, abandoned farmland is more susceptible to vegetation encroachment and uncontrolled wildfires, creating additional environmental and climate-related risks. The persistence of landmine contamination therefore represents not only a humanitarian and security challenge but also a major obstacle to environmental restoration, sustainable agriculture, and Ukraine's long-term green recovery.

4. Impacts of the War on Protected Areas and Biodiversity

Ukraine is recognized as one of Europe's biodiversity hotspots due to its diverse natural ecosystems, including forests, steppe landscapes, wetlands, mountain ecosystems, river valleys, and the coastal zones of the Black and Azov Seas. These ecosystems provide habitat for thousands of plant and animal species, many of which are endemic, endangered, or protected under international conservation agreements. Ukraine also plays an important role in maintaining ecological connectivity across Europe through the Emerald Network, Ramsar wetlands, UNESCO Biosphere Reserves, and other internationally significant protected areas.

The full-scale invasion has substantially increased pressures on these ecosystems. Military operations, occupation, defensive fortifications, artillery shelling, explosions, fires, pollution, and landmine contamination have caused extensive degradation of protected areas and natural habitats. Beyond the immediate physical destruction of ecosystems, these disturbances have altered ecological processes, fragmented habitats, disrupted species migration routes, and reduced the resilience of natural ecosystems.

According to official statistics [6], approximately 20% of Ukraine's protected areas have been affected by military activities or remain under temporary occupation. In addition, approximately 2.9 million hectares of Emerald Network sites are currently at risk, together with 16 Ramsar wetlands recognized as wetlands of international importance. Furthermore, 18 protected areas, including 8 strict nature reserves and 10 national nature parks, remain located within temporarily occupied territories, where environmental monitoring, conservation management, and scientific research cannot currently be carried out [7].

Figure 3 illustrates the spatial distribution of Ukraine's protected areas, including those affected by military activities and those located within temporarily occupied territories. Together, these findings underscore the unprecedented scale of the environmental pressures facing Ukraine's protected areas and biodiversity.

The continued occupation of these protected areas creates long-term challenges for biodiversity conservation. The absence of environmental management increases the risk of illegal logging, poaching, uncontrolled

fires, habitat degradation, and the spread of invasive species. Simultaneously, military activities disturb breeding sites, alter migration corridors, and increase mortality among wildlife populations. Sensitive ecosystems such as wetlands and coastal habitats are particularly vulnerable because even relatively small disturbances may result in long-lasting ecological changes.

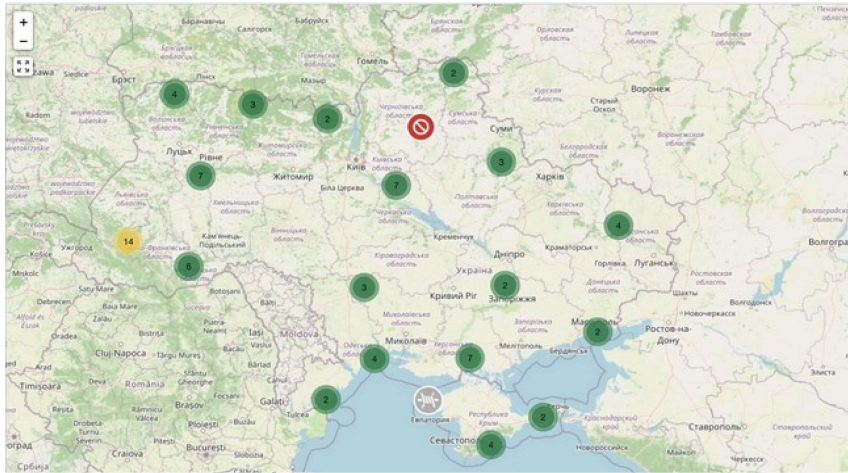


Figure 3. Ukraine's Protected Areas and Areas Affected by Military Activities and Temporary Occupation Source: *WOW Nature. Interactive Map of the Nature Reserve Fund of Ukraine* [7].

The impacts of the war extend well beyond the boundaries of individual protected areas. Habitat fragmentation reduces ecological connectivity between ecosystems, limiting the movement of species and decreasing ecosystem resilience to future environmental pressures, including climate change. Consequently, biodiversity loss caused by armed conflict should be considered not only a national environmental issue but also a regional European conservation challenge.

The deterioration of protected areas also affects the ecosystem services they provide, including carbon sequestration, water purification, soil conservation, flood regulation, and climate regulation. The degradation of these natural functions may significantly hinder Ukraine's post-war ecological recovery and reduce the capacity of ecosystems to contribute to long-term sustainable development.

Given the scale of environmental damage, the conservation and restoration of protected areas should become one of the highest priorities of Ukraine's post-war recovery. Achieving this goal will require comprehensive environmental monitoring, habitat restoration, ecological connectivity planning, mine clearance, and long-term international cooperation to safeguard biodiversity and strengthen ecosystem resilience.

5. Environmental War Crimes and Documented Environmental Damage

Since the beginning of the full-scale invasion, the systematic documentation of environmental damage has become an essential tool for assessing the overall environmental consequences of the war. The collection and analysis of verified environmental incidents provide important evidence for evaluating ecological losses, supporting environmental monitoring, and establishing legal accountability for violations of international environmental and humanitarian law. According to the SaveEcoBot Environmental Crimes Database, as of 14 July 2026, 961 war-related environmental crimes had been officially documented in Ukraine (Figure 4).

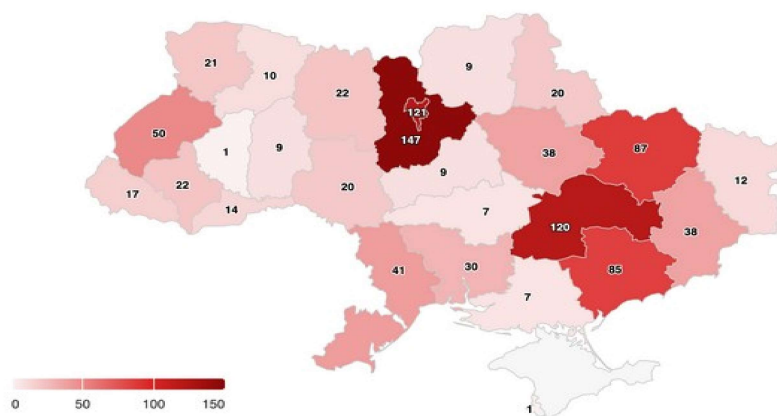


Figure 4. Spatial Distribution of Recorded Environmental Crimes in Ukraine (as of 14 July 2026) Source: SaveEcoBot. *Environmental Crimes Database* [8].

The spatial distribution of documented cases indicates that environmental damage has affected virtually the entire country, with the highest concentration observed in regions experiencing prolonged military ope-

rations, intensive shelling, or temporary occupation. Nevertheless, environmental incidents have also been recorded in regions located far from the active front line, reflecting the nationwide scale of the environmental impacts of the war.

The documented cases encompass a broad range of environmental impacts. As illustrated in Figure 5, the largest proportion (45.2%) falls within the category of other environmental offences, reflecting the diversity of environmental violations associated with military activities. Industrial accidents account for 21.6% of all recorded incidents, followed by damage to green areas (13.8%), contamination of water resources (8.5%), soil contamination (5.4%), military waste (2.9%), and incidents involving radiation facilities (2.5%). This distribution demonstrates that the environmental consequences of war extend across multiple environmental components, including terrestrial ecosystems, water resources, industrial infrastructure, and potentially hazardous facilities.

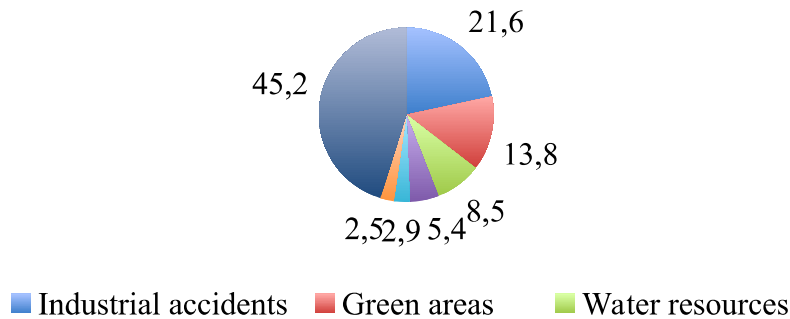


Figure 5. Distribution of Recorded Environmental Crimes by Category (as of 14 July 2026) *Source: SaveEcoBot. Environmental Crimes Database [8].*

Industrial accidents represent one of the most environmentally significant categories of recorded incidents. Damage to industrial enterprises, oil depots, chemical storage facilities, and energy infrastructure can result in the release of hazardous substances into the atmosphere, surface waters, groundwater, and soils. Such incidents frequently generate secondary environmental effects, including air pollution, toxic contamination, and long-term degradation of ecosystem functions.

The substantial proportion of cases related to green areas and soil

contamination reflects the extensive impacts of military operations on terrestrial ecosystems. Shelling, explosions, military fortifications, heavy vehicle movement, and wildfires contribute to vegetation loss, habitat destruction, soil degradation, and reduced ecosystem resilience. These impacts are further compounded by landmine contamination, which significantly limits ecological restoration and sustainable land use.

The documented environmental crimes demonstrate that environmental damage should not be regarded as an incidental consequence of armed conflict. Instead, the available evidence indicates a widespread and systematic pattern of environmental degradation affecting multiple ecosystem components throughout Ukraine. The long-term implications extend beyond immediate ecological losses, influencing biodiversity conservation, ecosystem services, public health, food security, and the country's capacity for sustainable post-war recovery.

Continued documentation of environmental crimes therefore serves not only as an important tool for environmental monitoring but also as a critical foundation for international legal proceedings, environmental damage assessment, and the development of effective strategies for ecological restoration and climate-resilient reconstruction.

6. Conclusions

The findings of this study demonstrate that the environmental consequences of the war in Ukraine extend far beyond the immediate areas of military operations and represent one of the most significant environmental crises in Europe in recent decades. Armed conflict has caused large-scale greenhouse gas emissions, extensive landmine contamination, soil degradation, damage to protected areas, biodiversity loss, and widespread environmental pollution, creating long-term risks for ecosystems, public health, food security, and sustainable development.

The analysis confirms that the environmental impacts of the war are multidimensional and closely interconnected. Military activities not only destroy natural ecosystems directly but also intensify climate change, reduce ecosystem resilience, disrupt ecological connectivity, and limit the provision of essential ecosystem services. At the same time, landmine contamination and environmental pollution significantly delay ecological

restoration and complicate the safe return of affected territories to productive use.

The documented environmental crimes further demonstrate that environmental degradation is not an isolated by-product of armed conflict but a widespread and systematic consequence of military aggression. Continued documentation of environmental damage is therefore essential for environmental monitoring, scientific assessment, international legal accountability, and the development of effective post-war recovery strategies.

Ukraine's post-war recovery should therefore integrate infrastructure reconstruction with ecosystem restoration, humanitarian demining, biodiversity conservation, climate change mitigation, and the principles of sustainable development and climate justice. Strengthening international cooperation, improving environmental monitoring systems, and incorporating environmental damage into international accountability and compensation mechanisms will be essential for building long-term ecological resilience and ensuring a sustainable green recovery.

Future research should focus on developing integrated methodologies for assessing cumulative environmental damage and evaluating the effectiveness of long-term ecological restoration policies in post-war Ukraine.

At the same time, the Ukrainian experience provides a unique empirical basis for advancing international legal approaches to documenting environmental damage, establishing environmental accountability, and developing compensation mechanisms for environmental harm caused by armed conflicts.

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