

**THE IMPACT OF MILITARY ACTIONS
ON THE ECOLOGICAL STATE OF UKRAINE'S
TERRITORIAL COMMUNITIES AND DIRECTIONS
FOR THE RESTORATION OF NATURAL ECOSYSTEMS**

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INTRODUCTION

The full-scale armed aggression of the Russian Federation against Ukraine, ongoing since 24 February 2022, has caused not only a humanitarian catastrophe but an environmental disaster unprecedented in scale, the consequences of which are felt at every level of the state's territorial organization – from the national level down to that of an individual territorial community. Hostilities, missile and artillery strikes, the mining of vast areas, the destruction of industrial and municipal facilities, as well as deliberate acts of environmental terrorism (above all, the destruction of the Kakhovka hydroelectric dam) have led to a cumulative environmental crisis affecting atmospheric air, surface and ground water, soils, forests, protected-area-fund sites, and biodiversity.

The relevance of this study stems from the fact that territorial communities, as the basic units of local self-government under decentralization, bear the main burden of the initial documentation of environmental damage, of ensuring the environmental safety of the population, and of planning environmental-recovery measures, while frequently lacking sufficient methodological, human-resource and financial capacity to carry out these tasks. International organizations – the United Nations Environment Programme (UNEP), the Organisation for Economic Co-operation and Development (OECD), and the Joint Research Centre of the European Commission – are conducting a systematic assessment of the environmental consequences of the war in Ukraine, providing an important empirical basis for the scholarly understanding of the problem at the regional and local levels.

The purpose of this chapter is to analyse the scale, nature and categories of the environmental damage inflicted on Ukraine's territorial communities as a result of hostilities, and to systematize the directions and practical

instruments for restoring natural ecosystems at the local level in the context of the country's post-war reconstruction.

Structurally, the chapter consists of two subsections. The first subsection analyses the scale, categories and regional differentiation of the environmental consequences of hostilities for territorial communities, in particular through the example of the Kakhovka dam breach. The second subsection systematizes the directions, instruments and institutional mechanisms for restoring natural ecosystems and the environmental rehabilitation of communities in the context of the state's post-war reconstruction.

1. The ecological state of territorial communities under armed aggression: scale, categories and consequences of destructive processes

Methodological foundations for classifying environmental damage.

The first systematic attempt to classify the environmental consequences of the war in Ukraine was made by UNEP in its 2022 preliminary review, which identifies five main categories of damage: impacts on the chemical industry and the handling of hazardous chemical substances; damage to fuel and associated infrastructure; disruption of waste-management systems; destruction of urban and critical infrastructure, including water supply; and damage to agriculture and natural ecosystems¹. This classification is methodologically universal and applicable to assessing the environmental state of individual territorial communities regardless of their location relative to the front line (Table 1).

The practical value of this classification for analysis at the level of a territorial community lies in the fact that it allows each category of damage to be linked to specific objects of local infrastructure and the economic complex that fall within the remit of local self-government bodies. At the same time, an independent perspective review of the war's environmental consequences confirms that the key drivers of environmental degradation are not only direct combat impacts but also associated processes – mass displacement of the population, disruption of logistical chains for handling hazardous waste, and the temporary suspension of environmental regulations under martial law.

Air pollution and health risks for the population of communities.

Shelling of industrial facilities, fires at fuel-and-lubricant and agricultural-produce storage sites, as well as large-scale fires in forest and steppe ecosystems, cause periodic but intense emissions of pollutants into the atmospheric air of territorial communities. Unlike the chronic industrial pollution of peacetime, wartime conditions are characterized by the unpredictability of sources and the

¹ United Nations Environment Programme. The Environmental Impact of the Conflict in Ukraine: A Preliminary Review. Nairobi : UNEP, 2022. 56 p.

episodic nature of large-volume emissions, which complicates both forecasting and the organization of systems for alerting the population to deteriorating air quality within a given community.

Table 1

Categories and nature of the environmental damage inflicted on Ukraine’s territorial communities as a result of hostilities

№.	Category of impact	Nature of the environmental damage	Examples of affected objects in territorial communities
1	Chemical industry and substances associated with the armed conflict	Emissions and spills of hazardous chemicals resulting from shelling of industrial facilities	Chemical, oil-refining and metallurgical enterprises in combat zones
2	Fuel and associated infrastructure	Contamination of soils and water with petroleum products, fires at fuel and energy facilities	Oil depots, filling stations, elements of communities’ energy infrastructure
3	Waste and waste-management infrastructure	Destruction of landfills and sorting stations, accumulation of construction and military debris	Municipal solid-waste landfills, destroyed community buildings
4	Urban and critical infrastructure	Damage to water supply, sewerage and wastewater treatment systems	Water utility facilities, treatment plants of territorial communities
5	Damage to agriculture and natural ecosystems	Soil degradation, biodiversity loss, damage to protected areas	Arable land, forests, protected-area-fund objects of communities

Source: compiled by the author

A perspective analytical review emphasizes that armed conflict creates a specific class of environmental risks associated with breaches to the integrity of hazardous facilities located within or near populated areas, including the risk of secondary technogenic accidents at chemically hazardous sites. For territorial communities on whose territory such facilities are located, this necessitates the advance mapping of potential sources of air pollution and the integration of this information into local civil-protection plans.

Degradation and contamination of the soil cover. A special place among studies of the war’s environmental consequences is occupied by research on qualitative changes in the state of the soil cover, based on a combination of field measurements and remote-sensing methods, which record soil degradation and contamination in zones of active hostilities². The combined approach – field

² Solokha M., Pereira P., Symochko L., Vynokurova N., Demyanyuk O., Sementsova K., Inacio M., Barceló D. Russian-Ukrainian war impacts on the environment: Evidence from the field on soil properties and remote sensing. *Science of the Total Environment*. 2023. Vol. 902. Art. 166122. DOI: 10.1016/j.scitotenv.2023.166122.

sampling together with satellite data – makes it possible not only to confirm the fact of contamination but also to trace its spatial dynamics over large territories that are inaccessible for comprehensive field surveys under ongoing hostilities.

Researchers distinguish several main types of impact of hostilities on the soil cover: mechanical disturbance of soil structure caused by the digging of fortifications, the movement of heavy machinery and explosions; chemical contamination from munition-detonation products, heavy metals and residual rocket fuel; and indirect degradation caused by the cessation of agrotechnical measures (tillage, fertilization, erosion-control measures) on land temporarily withdrawn from economic use due to the danger of mines.

A generalizing study of the scale of land degradation and contamination resulting from the armed conflict at the national level confirms the systemic nature of these processes and the need to develop a unified methodology for assessing soil quality on territories affected by hostilities³. For territorial communities located in the front-line zone and on de-occupied territories, these processes are decisive for assessing the suitability of agricultural land for further economic use, as well as for planning the priority of humanitarian demining and reclamation works. An additional risk factor is the presence of explosive objects in the upper soil horizons, which makes it impossible to conduct a conventional soil survey without a prior pyrotechnic inspection of the territory.

Damage to critical infrastructure and waste-management systems.

A separate group of consequences, distinguished in the UNEP classification, consists of damage to urban and critical infrastructure, above all water supply, sewerage and waste-management systems. For territorial communities, the destruction of water-utility facilities means not only a temporary loss of access to drinking water but also the risk of untreated wastewater uncontrollably entering surface water bodies, which increases the burden on already vulnerable aquatic ecosystems, discussed below.

At the same time, the war has created an unprecedented burden on territorial communities' systems for handling household and construction waste: the destruction of residential buildings generates significant volumes of construction debris, often mixed with hazardous components (asbestos-containing materials, residual fuel and lubricant substances), while some existing solid-waste landfills have themselves been damaged or have temporarily lost access to environmental-safety monitoring systems. The lack of sorting and proper handling of this mixed waste stream increases, in the

³ Solokha M., Demyanyuk O., Symochko L., Mazur S., Vynokurova N., Sementsova K., Mariychuk R. Soil degradation and contamination due to armed conflict in Ukraine. *Land*. 2024. Vol. 13, No. 10. Art. 1614. DOI: 10.3390/land13101614.

medium term, the risk of secondary contamination of soils and groundwater in areas adjacent to landfills.

A specific challenge for territorial communities is also the accumulation of waste of military origin – remnants of weapons, munitions and military equipment – the handling of which requires specialized pyrotechnic and environmental procedures that go beyond the ordinary competence of municipal services. This necessitates the creation, at the regional level, of specialized facilities for the safe disposal of this type of waste, accessible to several territorial communities simultaneously.

Impact on agriculture and food security of communities. The agricultural sector of territorial communities is affected by the war along several interrelated dimensions: physical destruction of agricultural infrastructure (grain elevators, livestock complexes, land-reclamation systems), temporary or permanent loss of access to land due to the danger of mines, and deterioration of the qualitative characteristics of soils on land that remains in economic use⁴. These processes directly affect the food security and economic resilience of territorial communities for which agriculture has traditionally been the basis of the local economy.

Studies of changes in the physico-chemical properties of soils, based on field measurements and remote sensing, record, in particular, increased soil density resulting from the movement of heavy machinery, disruption of the natural structure of the arable layer, and localized contamination from detonation products, which together reduce the potential yield of affected land even in the absence of direct chemical contamination capable of rendering economic use impossible. For territorial communities, this implies the need for a differentiated approach to planning the restoration of agricultural production – prioritizing the return to use of land with a minimal degree of damage, coupled with the phased reclamation of more severely affected plots.

Water ecosystems of territorial communities. No less vulnerable are the surface water bodies of territorial communities: a telling case is that of the Irpin River basin, for which changes in the structure of microalgae and macrophyte communities have been documented as a result of war-related anthropogenic activity⁵, in particular due to changes in the hydrological regime caused by the destruction of hydraulic structures in 2022, as well as the influx of pollutants

⁴ Rawtani D., Gupta G., Khatri N., Rao P. K., Hussain C. M. Environmental damages due to war in Ukraine: A perspective. *Science of the Total Environment*. 2022. Vol. 850. Art. 157932. DOI: 10.1016/j.scitotenv.2022.157932.

⁵ Nezbrytska I., Bilous O., Sereda T., Ivanova N., Pohorielova M., Shevchenko T., Dubniak S., Lietytska O., Zhezherya V., Polishchuk O. et al. Effects of war-related human activities on microalgae and macrophytes in freshwater ecosystems: A case study of the Irpin River Basin, Ukraine. *Water*. 2024. Vol. 16, No. 24. Art. 3604. 17 p. DOI: 10.3390/w16243604.

from destroyed wastewater-management infrastructure. The recorded changes in the structure of aquatic communities are regarded by researchers as an indicator of broader, often visually imperceptible, disruptions to the functioning of freshwater ecosystems.

The case of the Irpin River basin has important methodological significance for territorial communities located in the basins of other affected rivers, as it demonstrates the value of incorporating hydrobiological monitoring – not merely chemical analysis of water-quality indicators – into standard environmental-assessment procedures. Structural changes in microalgae and macrophyte communities can signal disruption of an aquatic ecosystem long before corresponding changes become apparent through conventional chemical water-quality indicators, making biological monitoring an important complement to the existing control systems used by territorial communities.

Protected-area fund and biodiversity. Particular attention should be paid to the impact of hostilities on protected-area-fund sites: studies confirm that Ukraine's protected areas have suffered substantial direct and indirect impacts from hostilities, including physical destruction, fires and breaches of protection regimes⁶. Direct impact manifests as the physical destruction of vegetation cover due to explosions and fires caused by hostilities, while indirect impact is associated with the impossibility of carrying out planned conservation measures (population regulation, control of invasive plants, fire-prevention work) on territories to which access is restricted for security reasons.

Since a significant share of protected-area-fund sites are located within or near the territorial communities of front-line and de-occupied regions, this issue must be considered in inseparable connection with local environmental-recovery programmes. Researchers emphasize the need to restore the protected status and functions of the most valuable territories as soon as possible after the end of active hostilities, since a prolonged absence of a protection regime increases the risk of irreversible biodiversity loss, in particular of rare and endangered species.

The case of the Kakhovka dam breach. The single most destructive act from an environmental standpoint was the breach of the Kakhovka hydroelectric dam in June 2023. A rapid environmental assessment conducted by UNEP at the request of the Government of Ukraine established that a significant share of the damage caused by the breach is irreversible, and that the hydrological, geomorphic, chemical and ecological consequences extend to territories both

⁶ Leal Filho W., Fedoruk M., Eustachio J. H. P. P., Splodytel A., Smaliychuk A., Szykowska-Jóźwik M. I. The environment as the first victim: The impacts of the war on the preservation areas in Ukraine. *Journal of Environmental Management*. 2024. Vol. 364. Art. 121399. DOI: 10.1016/j.jenvman.2024.121399.

upstream and downstream of the dam, including protected-area-fund sites⁷ (Table 2, Fig. 1). The assessment drew on official data, satellite imagery and remote-sensing methods, since the security situation in the combat zone limited the possibilities for conducting full-scale field studies.

The consequences of the breach differ depending on a territory’s position relative to the dam. Upstream of the dam, the rapid drawdown of the Kakhovka reservoir caused a change in the hydrological regime of adjacent territories, disrupted the functioning of water-supply systems that depended on the reservoir, and altered the conditions for aquatic and riparian ecosystems that had developed over decades of the reservoir’s existence. Downstream of the dam, large-scale flooding led to the inundation of settlements, agricultural land and natural territories, including areas within the Black Sea Biosphere Reserve.

For the territorial communities of Kherson and adjacent oblasts, this event caused a comprehensive transformation of the hydrological regime, the loss of agricultural land through flooding and subsequent desiccation, and long-term risks to drinking-water supply systems, a significant share of which had depended on a stable water level in the reservoir. Of particular note is that UNEP’s assessment classified a significant share of the damage as irreversible – this concerns, in particular, the loss of riparian and wetland ecosystems formed over decades, the restoration of which in their original form is practically impossible even with the complete reconstruction of hydraulic infrastructure.

Table 2

Consequences of the Kakhovka dam breach for natural ecosystems

Indicator of the dam-breach consequences	Value / characteristic
Area of affected natural and semi-natural habitats	over 500 thousand ha upstream and downstream of the dam
Number of potential pollution sources flooded as a result of the breach	over 1000 sites (treatment plants, filling stations, landfills, industrial enterprises)
Protected areas affected	the Black Sea Biosphere Reserve and other areas of national and international importance
Type of damage caused	hydrological and geomorphic changes, chemical contamination, waste accumulation, ecosystem degradation
Reversibility of the consequences	a significant share of the damage is classified as irreversible; consequences are projected to last decades

Source: compiled by the author

⁷ United Nations Environment Programme. *Rapid Environmental Assessment of Kakhovka Dam Breach, Ukraine, 2023*. Nairobi : UNEP, 2023. XIII, 115 p. DOI: 10.59117/20.500.11822/43696.

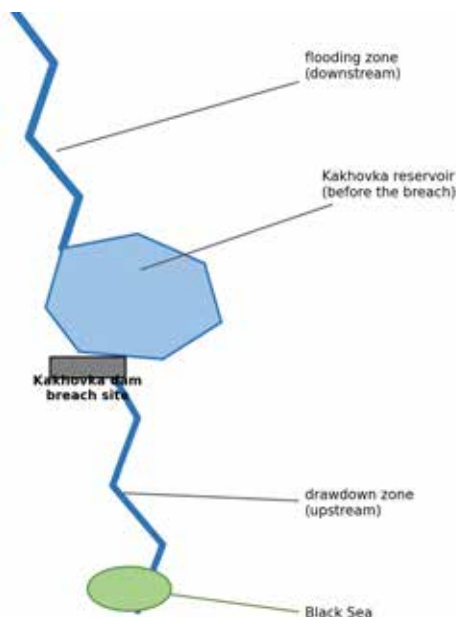


Fig. 1. Schematic map of the spread of environmental consequences of the Kakhovka dam breach along the Dnipro river basin (simplified, not a cartometric base; prepared by the author)

Special attention should be paid to the indirect consequences of the breach for irrigation and industrial water-supply systems: the Kakhovka reservoir historically supplied water to a significant share of the irrigation systems of the southern oblasts of Ukraine and also served as a source of technical water for a number of industrial facilities in the region, including the cooling systems of large energy facilities located in the lower Dnipro basin. The loss of a stable water source for these systems poses a long-term risk both to agricultural production in the territorial communities of the southern region and to broader industrial and energy security, extending well beyond purely environmental concerns.

In comparative terms, the Kakhovka dam breach is regarded by researchers as one of the largest technogenic incidents caused by the armed conflict, in terms of the area affected, the number of ecosystem functions disrupted, and the projected duration of recovery. Unlike point sources of pollution (individual industrial facilities or fuel depots), the consequences of the breach display

a pronounced cascading character: the change in hydrological regime triggers further changes in soil conditions and the structure of plant communities, and ultimately in the living conditions of the population of nearby territorial communities, which complicates both the assessment of the overall scale of damage and the planning of comprehensive recovery measures.

Regional differentiation of environmental consequences. A synthesis of the material analysed makes it possible to state that the intensity and nature of environmental consequences differ substantially depending on a territorial community's position relative to the front line. For front-line and temporarily occupied territorial communities (in particular, significant parts of Kharkiv, Luhansk, Donetsk, Zaporizhzhia and Kherson oblasts), the maximum intensity of destructive processes is characteristic – direct destruction of infrastructure, fires, the mining of large areas, and the practical impossibility of conducting environmental or recovery measures before the end of hostilities.

For communities in de-occupied territories (individual districts of Chernihiv, Sumy, Kyiv, Mykolaiv and Kherson oblasts), the defining tasks are related to humanitarian demining, the reclamation of disturbed land, and the restoration of damaged infrastructure, whereas the direct threat of hostilities is already absent. Rear-area communities – mostly in the central and western oblasts – mostly experience secondary consequences of the war: an increased burden on local waste-management systems due to the placement of internally displaced persons, changes in the water regime of transit water bodies, and logistical and economic effects associated with the redirection of production and transport flows. A schematic regional differentiation is presented in Fig. 2.

Managerial and socio-economic consequences for territorial communities. In addition to purely environmental consequences, hostilities generate a number of managerial challenges for the local self-government bodies of territorial communities. These include, in particular, the need for the initial documentation of environmental damage for the purposes of subsequent compensation, the limited human-resource capacity of local environmental services, and the lack of unified methodological guidance on a community's course of action in the event of detecting pollution or damage to natural objects under martial law.

An additional challenge is the financial capacity of communities: a significant share of the budgets of territorial communities affected by hostilities is directed toward urgent humanitarian and reconstruction needs, while environmental measures – monitoring, reclamation, restoration of natural objects – require separate, often long-term financing, sources of which are largely absent at the local level. This underscores the critical importance of external – state and international – support, a matter examined in more detail in the second subsection.

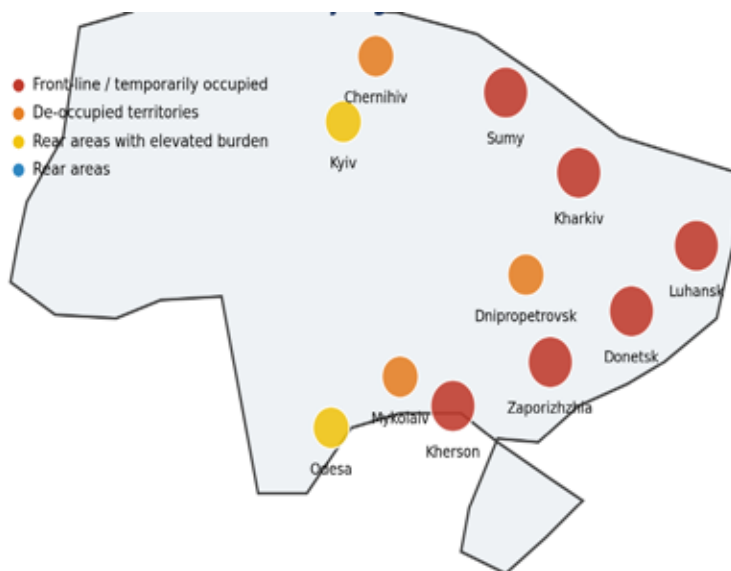


Fig. 2. Schematic map of the regional differentiation of environmental consequences of hostilities for territorial communities of Ukraine (simplified, not a cartometric base; prepared by the author)

No less important is the issue of documenting the environmental damage inflicted, for the purposes of subsequent compensation – both within national compensation mechanisms and in the context of possible international-legal procedures to hold the aggressor state accountable for damage to the environment. Rigorous, methodologically sound documentation of pollution incidents at the level of a territorial community – linked to specific objects, dates and, where possible, laboratory-analysis results – forms an evidentiary base whose significance extends far beyond purely environmental tasks and acquires weight in the broader context of post-war justice.

These managerial challenges indicate that the environmental restoration of territorial communities is not merely an environmental issue but a complex socio-economic and institutional problem, the resolution of which requires coordinated action at all levels of public administration – from an individual village, settlement or city council to the central executive authorities and Ukraine’s international partners.

A qualitative comparison of the relative prominence of the categories of environmental damage discussed above in the sources reviewed is presented in a supplementary Excel file accompanying this chapter.

Summarizing the material presented in this subsection, it can be stated that the environmental state of Ukraine's territorial communities under armed aggression is characterized by a combination of direct (physical destruction, contamination) and indirect (managerial, socio-economic) consequences, the intensity of which is determined both by the nature of hostilities and by the natural-economic specifics of a given territory. This forms the basis for developing differentiated, rather than uniform, strategies for restoring natural ecosystems, which are the subject of the second subsection.

2. Directions for the restoration of natural ecosystems and strategies for the ecological rehabilitation of territorial communities

Monitoring and assessment of the environmental state. Formulating an effective strategy for the post-war environmental recovery of territorial communities requires a consistent combination of several interrelated directions. The methodological basis for planning recovery measures is systematic monitoring and assessment of the environmental state using remote sensing of the Earth combined with field studies, which makes it possible to record the dynamics of degradation processes promptly and objectively, even in territories with limited physical access. The quality of the source monitoring data directly determines the effectiveness of subsequent planning of recovery measures at the national and regional levels.

In the practice of environmental monitoring of territories affected by the war in Ukraine, a combination of several types of instruments is applied – from international satellite emergency-response services to local observation systems operating directly within a territorial community (Table 3). For local self-government bodies, what matters is not so much direct access to complex geospatial platforms as the ability to interpret and use the results of such monitoring when planning priority recovery measures, as well as to establish cooperation with the relevant state and international bodies that possess the corresponding technical capabilities.

An important complement to remote methods is the development of local civic (citizen) environmental-monitoring systems, which allow residents of territorial communities to independently record cases of air, water or soil pollution and pass the relevant information on to the responsible authorities. Despite limited metrological accuracy compared with official instrumental observations, this form of monitoring plays an important role in the prompt detection of local environmental incidents, especially in territories with a limited presence of state regulatory bodies during periods of active hostilities.

Table 3

**Examples of environmental-monitoring tools and platforms
applicable to territorial communities**

Tool / platform	Purpose	Level of application
Copernicus Emergency Management Service (EU)	Satellite monitoring of emergencies, mapping of affected areas	International / national
PREEO (UNEP rapid environmental assessment methodology)	Structured field and remote assessment of the environmental consequences of conflict	International
Geospatial services of Ukrainian remote-sensing providers	Analysis of damage to land, crops and infrastructure based on satellite imagery	National / regional
Interactive maps of environmental incidents (state and civic initiatives)	Recording reports of pollution, fires and discharges accessible to communities	Regional / local (community)
Local environmental monitoring systems of territorial communities	Regular monitoring of air, water and soil conditions within a specific community	Local (community)

Source: compiled by the author

Building the human-resource and methodological capacity of communities. The effective use of monitoring results at the level of a territorial community is impossible without appropriate human-resource and methodological training of local self-government officials. Practice indicates an uneven institutional capacity among Ukraine's territorial communities to work with environmental data, which justifies the development of centralized training programmes and methodological guidance adapted to the needs of communities with varying levels of resource availability.

In this context, an important role can be played by higher-education institutions specializing in environmental, geographical and natural sciences, which can act as methodological partners of territorial communities – both in training specialists for local self-government bodies and in directly supporting individual environmental-assessment and recovery projects on a contractual or grant basis. Such a format of cooperation simultaneously addresses the task of providing natural-science students with practical training on real-world cases and strengthens the methodological capacity of communities.

Soil remediation and humanitarian demining. The second key direction is the remediation of contaminated and disturbed land in territorial communities, encompassing humanitarian demining, soil reclamation, and the elimination of chemical and oil-contamination hotspots. In its analysis of the prospects for a green reconstruction, the OECD emphasizes the merit of integrating environmental priorities directly into the process of post-war infrastructure

reconstruction, rather than treating them as a separate, secondary task⁸, which is of fundamental importance precisely at the level of the territorial community, where the reconstruction of housing stock, roads and municipal infrastructure inevitably involves earthworks.

Humanitarian demining is a prerequisite for any further recovery measures across much of the de-occupied and formerly front-line territories, since without it neither a full-scale field soil survey nor practical land reclamation is possible. Studies of land degradation and contamination resulting from the armed conflict point to the merit of combining demining with the parallel collection of soil samples for subsequent chemical analysis, which shortens the overall time required to return land to safe economic use.

Reclamation measures for territorial communities should be differentiated according to the type and intensity of contamination: for territories with mechanical disturbance of the soil cover (craters, trenches, tracks left by heavy machinery), measures to restore the terrain and fertile layer are the priority; for territories with chemical contamination, containment and, where necessary, removal of contaminated soil followed by disposal or neutralization; for agricultural land withdrawn from cultivation for a prolonged period, the phased restoration of agrotechnical practices with due regard to the changes in soil physico-chemical properties recorded by field studies.

Given the limited resources available to most territorial communities, a phased approach to land remediation is practically advisable: at the first stage – demining and surveying territories of the highest priority for use (land near settlements, plots with the best agro-productive characteristics); at the second stage – reclamation of land with a moderate degree of damage; at the third, long-term stage – restoration of the most complex, heavily contaminated or structurally disturbed plots, which may require specialized remediation technologies unavailable at the level of an individual community without external technical support. The OECD emphasizes that precisely such consistent, phased planning, aligned with a realistic assessment of available resources, is the key to avoiding a situation in which begun but unfinished reclamation works create additional, secondary environmental risks.

Restoration of water bodies. The third direction concerns the restoration of aquatic ecosystems – the reconstruction of hydraulic structures, the cleanup of water bodies from pollutants, and the restoration of the natural hydrological regime of rivers and reservoirs affected both by direct destruction (above all in the Dnipro basin following the Kakhovka dam breach) and by the indirect

⁸ OECD. Environmental impacts of the war in Ukraine and prospects for a green reconstruction. OECD Policy Responses on the Impacts of the War in Ukraine. Paris : OECD Publishing, 2022. 11 p. DOI: 10.1787/9e86d691-en.

anthropogenic burden of wartime, documented in particular for the Irpin River basin.

For territories affected by the Kakhovka dam breach, recovery measures must take into account the dual nature of the damage caused: upstream of the dam – measures aimed at stabilizing the hydrological regime and restoring water-supply systems that depended on the reservoir; downstream of the dam – measures to restore the natural state of floodplain and riparian ecosystems, as well as to eliminate the consequences of the flooding of settlements and agricultural land. Given the significant irreversibility of part of the damage, as established by international experts, the recovery strategy should be oriented not toward the literal reproduction of the previous state but toward the formation of a new, environmentally resilient state of the affected territories.

For territorial communities located in the basins of smaller rivers, affected by the indirect anthropogenic burden of wartime, priority measures include the restoration of wastewater-treatment systems, the elimination of unauthorized discharges, and the restoration of natural vegetation along riparian buffer zones, which performs an important buffering function against pollution entering from adjacent territories.

A separate task, closely linked to the restoration of aquatic ecosystems, is the reconstruction of drinking-water supply and sewerage systems, damage to which was recorded among the principal categories of environmental damage as early as UNEP's preliminary review. For territorial communities, the restoration of such systems should be regarded not merely as an engineering task but also as a component of a broader strategy for restoring aquatic ecosystems, since the quality of wastewater treatment directly determines the burden placed on receiving water bodies. This warrants coordination between water-utility enterprises and the relevant environmental services of a community when planning the sequence of reconstruction works.

Restoration of forest and protected ecosystems. The fourth direction is the restoration of forest and protected ecosystems. Research on pathways for Ukraine's post-war nature recovery, focused on forest socio-ecological systems, emphasizes the importance of combining active reforestation with support for natural succession processes, as well as the need to reconcile economic and conservation interests in communities where forests simultaneously perform resource, protective and recreational functions⁹. This approach allows territorial communities to view forest restoration not only as an environmental resource but also as a socio-economic resource for local development.

⁹ Melnykovych M., Nijnik M., Soshenskyi O. et al. Pathways for Ukraine's post-war nature recovery: Focus on forest socio-ecological systems. *Ambio*. 2026. Vol. 55. P. 817–843. DOI: 10.1007/s13280-025-02263-0.

Researchers note that the choice between active reforestation (artificial planting) and support for natural succession should be made with regard to the specific conditions of a given territory – the degree of soil-cover damage, the presence of mine danger, the availability of locally sourced planting material, and the community's long-term goals for the use of forest resources. In cases of significant contamination or mechanical soil disturbance, natural succession may prove a slower but ecologically more resilient alternative to artificial reforestation.

For protected-area-fund sites that have suffered direct or indirect impacts from hostilities, the priority task is the swiftest possible restoration of the protection regime and the corresponding management functions, since a prolonged absence of oversight increases the risks of illegal resource use, spontaneous fires and poaching on these territories. Territorial communities within whose boundaries such sites are located can play an active role in restoring the protection regime by organizing civic oversight and involving the local population in conservation measures.

The concept of forest socio-ecological systems, which underlies research on pathways for Ukraine's post-war nature recovery, entails viewing a forest not merely as an aggregate of woody vegetation but as a complex system of interaction among natural processes, economic use, and local communities dependent on forest resources. A practical implication of this approach for territorial communities is the need to align state (sectoral) reforestation programmes with local interests – the recreational use of forests, traditional forms of use of non-timber forest resources, and the role of forest tracts in protecting agricultural land from erosion and adverse climatic phenomena, the significance of which is growing under climate change.

Researchers also highlight the risk of a conflict of interest between rapid commercial restoration of tree stands (dominated by monoculture plantations of fast-growing species) and the long-term goal of restoring biologically diverse, resilient forest ecosystems. For territorial communities primarily interested in the fastest possible restoration of the protective and recreational functions of forests, this creates a need for a conscious choice between faster but potentially less resilient solutions and longer, yet more ecologically sound, reforestation strategies that combine artificial planting with support for natural succession on the plots best suited to it.

Institutional and legal support and financing for recovery. The fifth, institutional-legal direction involves integrating the principles of sustainable and green recovery into the local development strategies of territorial communities, aligning them with national reconstruction programmes, and attracting international technical and financial support. The success of green recovery depends to a large extent on how consistently environmental criteria are

integrated into the decision-making system at every level of governance – from the national to the local – including the procedures for planning and financing reconstruction projects at the territorial-community level.

Analytical materials of the Joint Research Centre of the European Commission on the state of the environment and climate in Ukraine emphasize that integrating the environmental dimension into the post-war reconstruction process is not only an internal need of the state but also an important precondition for further European integration, since a significant share of the EU's environmental legislation (the *acquis communautaire* in the field of the environment) will need to be progressively implemented at the national and regional levels¹⁰. For territorial communities, this means the need to progressively adapt local regulatory practices to European standards of environmental governance, in particular in the areas of waste management, water quality, and environmental impact assessment.

The practical dimension of such adaptation includes, in particular, the gradual alignment of local waste-handling practices with the waste hierarchy (prevention, reuse, recycling, disposal) enshrined in EU environmental legislation, the introduction of a river-basin approach to water-resource management, and the phased extension of environmental-impact-assessment procedures to a wider range of recovery projects implemented within territorial communities. Although full implementation of these approaches is a task for the national level, territorial communities that begin adapting their own practices to the relevant standards at an early stage gain an additional advantage when preparing applications for European financing.

Climate resilience of restored ecosystems. The planning of natural-ecosystem restoration in territorial communities should be carried out with due regard not only for the damage caused by the war but also for long-term climatic trends, since ecosystems restored without accounting for this factor risk proving vulnerable to droughts, rising temperatures, or changes in precipitation patterns characteristic of most regions of Ukraine. It is advisable to combine the tasks of post-war environmental recovery with the tasks of climate-change adaptation, in particular through the selection of drought-resistant species during reforestation and the prioritization of measures that simultaneously increase ecosystem resilience and reduce the climate-related vulnerability of territorial communities.

The formation of mixed-age and mixed-species stands, rather than monoculture plantations, is likewise advisable for reasons of long-term resilience

¹⁰ Belis C. A., Petrosian A., Turos O. et al. Status of Environment and Climate in Ukraine: Assessing the Impact of War and Its Implications for Reconstruction. Luxembourg : Publications Office of the European Union, 2025. JRC141480. DOI: 10.2760/6292177.

to climatic and other stress factors, including the risk of repeated fires and pests. For territorial communities, this means that decisions which at first glance appear purely environmental in nature have, in the long term, a direct bearing on the climatic and economic resilience of the local community as a whole.

Financing environmental-recovery measures at the level of territorial communities requires a combination of several sources: the state budget within national reconstruction programmes, international technical and financial assistance, and the attraction of private investment through public-private partnership mechanisms (Table 4). The practice of preparing applications for international financing of environmental projects requires territorial communities to build a solid evidentiary base regarding the damage inflicted, which further underscores the importance of the systematic monitoring discussed above.

Table 4

**Typology of financing sources for environmental-recovery measures
in territorial communities**

Source of financing	Characteristics	Suitability for the community level
State budget (national recovery programmes)	Centralized financing of priority recovery projects	Through regional coordination mechanisms
International technical and financial assistance	Grants and programmes of international organizations and donors for environmental projects	Direct community participation in competitive procedures
EU pre-accession funds and programmes	Support for adaptation to EU environmental legislation	Through national/regional programme operators
Public-private partnership	Attraction of private investment into recovery infrastructure	Where investment-attractive community projects exist

Source: compiled by the author

Practice shows that territorial communities with more developed institutional capacity – the presence of qualified specialists, experience in preparing project applications, and established cooperation with regional and central authorities – have substantially higher chances of attracting external financing compared with communities that rely solely on their own resources. This creates a risk of deepening the unevenness of recovery among territorial communities, which justifies targeted methodological support for communities with limited capacity from regional administrations, relevant ministries and partner organizations.

The role of territorial communities and public participation in recovery. The practical implementation of the directions presented depends to a large extent on the capacity of territorial communities themselves to act

not as passive recipients of assistance but as active subjects of the planning and implementation of recovery measures. This entails establishing, within the structure of local self-government bodies, units or officials responsible for coordinating environmental issues, developing local environmental-rehabilitation programmes, and maintaining ongoing communication with the population regarding the state of the environment within the community.

Involving the residents of territorial communities in recovery measures – through civic monitoring, participation in reforestation campaigns, and oversight of compliance with the protection regime of local natural areas – is not merely an additional resource for local self-government bodies with limited human-resource capacity but also an important factor in building public support for long-term, often costly, environmental-recovery programmes. The experience of citizen science in the field of environmental monitoring, which has become more widespread in Ukraine in recent years, demonstrates the potential of such involvement given appropriate methodological support from relevant specialists and educational institutions, including higher-education institutions that train specialists in the environmental and natural sciences.

Practical forms for institutionalizing public participation in territorial communities can include standing or ad hoc advisory bodies on environmental recovery (community environmental councils attached to local self-government bodies), the inclusion of environmental projects in participatory (community) budgeting procedures, and cooperation agreements with relevant civic organizations and higher-education institutions for the joint implementation of specific components of a local environmental-rehabilitation programme. Engaging a broad range of stakeholders, including local communities, improves both the quality of recovery-measure planning and the level of public trust in their implementation, which is especially important given the constrained resources of the post-war period.

At the same time, researchers caution against formal, purely declarative public involvement that is not accompanied by real influence on decision-making: effective community participation requires transparent access to environmental-monitoring results, an explanation of the data obtained that is comprehensible to a non-specialist audience, and a clear indication of how residents' proposals and comments are taken into account when adjusting a local environmental-rehabilitation programme.

The monitoring-recovery cycle: the importance of feedback. An important methodological principle uniting all the directions discussed is the understanding of natural-ecosystem restoration not as a one-off set of measures but as a cyclical process that requires constant feedback between monitoring and practical action. The results of an initial assessment of

a territory’s environmental state determine the priority and content of recovery measures, while subsequent, repeat monitoring makes it possible to evaluate their effectiveness and, if necessary, to adjust the strategy adopted.

For territorial communities, the practical implementation of such a cycle means the need to build repeat (control) surveys into the plan of any recovery project – whether the reclamation of a contaminated plot, reforestation works, or measures to clean up a water body. The absence of such control creates a risk of inefficient expenditure of a community’s limited resources on measures whose real effectiveness remains unconfirmed, and also complicates the justification of further applications for external financing, which typically require demonstration of the results of previous stages of work.

A generalized model for a territorial community’s environmental-rehabilitation programme. A synthesis of the directions discussed makes it possible to propose a generalized sequence of actions for a territorial community when developing its own environmental-rehabilitation programme: inventory and categorization of the environmental damage sustained, in accordance with the classification presented in Table 1; determination of the priority of recovery directions taking into account available resources and the degree of risk to the population; alignment of the local programme with regional and national reconstruction strategies; and the formulation of a plan for attracting external financing and technical support (Table 5, Fig. 3).

Table 5

**Directions and instruments for the restoration of natural ecosystems
in territorial communities**

Restoration direction	Main measures at the territorial-community level	Expected outcome
Monitoring and assessment	Remote sensing, field surveys, local environmental monitoring systems	Up-to-date picture of the community’s environmental state, basis for planning
Soil and land remediation	Humanitarian demining, reclamation of disturbed land, elimination of pollution hotspots	Return of land to safe economic use
Restoration of water bodies	Restoration of hydrological regime, cleanup of water bodies, reconstruction of water infrastructure	Improved water quality, restored aquatic ecosystems
Restoration of forest and protected ecosystems	Reforestation, support for natural succession, expansion of the protected-area fund	Conservation of biodiversity, increased ecosystem resilience
Institutional and legal support	Integration of green-recovery principles into local development strategies, attraction of international support	Alignment of community actions with national recovery policy

Source: compiled by the author

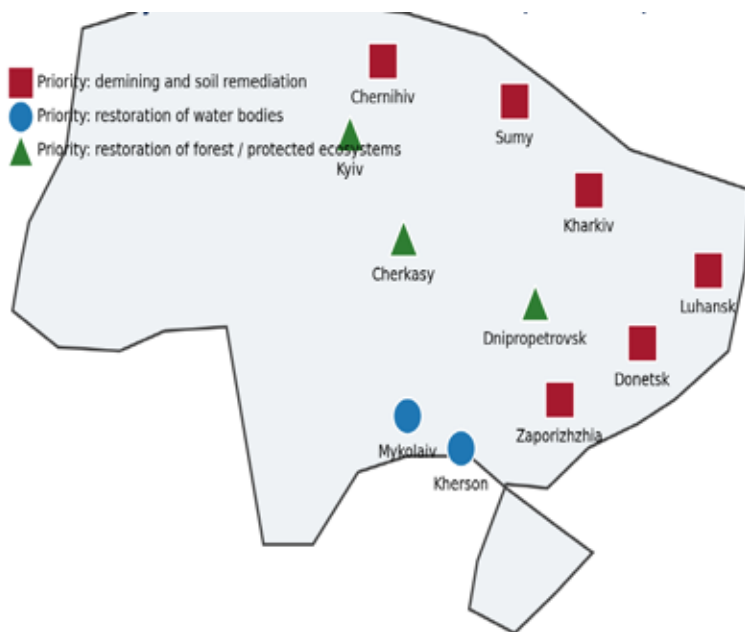


Fig. 3. Schematic map of priority directions for the restoration of natural ecosystems of Ukraine's territorial communities (simplified, not a cartometric base; prepared by the author)

The generalized model presented is not a rigid algorithm but rather a methodological reference point, which each territorial community must adapt to its own specific circumstances – the nature and scale of the damage sustained, available natural resources, and the human-resource and financial capacity of local self-government bodies. At the same time, the availability of such a reference point ensures a minimum level of methodological consistency among the environmental-rehabilitation programmes of different territorial communities, which is an important precondition for their further coordination at the regional and national levels.

In summary, effective restoration of the natural ecosystems of territorial communities is possible only through a comprehensive combination of technical (monitoring, remediation, reconstruction), environmental (forest and biodiversity restoration), and institutional-managerial (legal support, financing, community participation) components, discussed in this subsection.

CONCLUSIONS

The analysis conducted demonstrates that hostilities have caused a multidimensional environmental crisis which, at the level of territorial communities, manifests itself in the pollution of atmospheric air, soils and water bodies, the destruction of critical infrastructure, land degradation, and biodiversity loss, with the intensity of these processes varying substantially depending on a community's position relative to the front line. The most destructive factor is the combination of direct combat impacts with technogenic disasters triggered by the war, the most illustrative example being the Kakhovka dam breach, the consequences of which have been recognized as largely irreversible.

Restoring the natural ecosystems of territorial communities requires a comprehensive approach combining systematic monitoring, the remediation of contaminated territories, the restoration of aquatic and forest ecosystems, and institutional-legal support for integrating environmental priorities into local development strategies. The practical capacity of territorial communities to implement such programmes depends to a large extent on access to external financing, methodological support, and the active participation of the local population.

Prospects for further research are associated with developing a methodology for the quantitative assessment of environmental damage at the level of an individual territorial community, forming standard models of local environmental-rehabilitation programmes for communities in different categories of affected territories, and studying the long-term dynamics of ecosystem recovery following the Kakhovka dam breach as the largest technogenic incident of the war from an environmental standpoint.

SUMMARY

This chapter examines the impact of hostilities caused by the full-scale armed aggression of the Russian Federation against Ukraine on the ecological state of territorial communities and substantiates directions for the restoration of natural ecosystems. The international classification of categories of war-inflicted environmental damage is systematized and adapted for analysis at the level of a territorial community. The scale of soil-cover degradation, water-body contamination, and damage to protected areas resulting from hostilities is examined, along with the managerial and socio-economic consequences for local self-government bodies. Particular attention is devoted to the breach of the Kakhovka hydroelectric dam in June 2023 as the most destructive single act of environmental impact of the war, the consequences of which are recognized as largely irreversible. It is shown that the intensity of environmental consequences is differentiated according to a community's position relative to the front

line – front-line, de-occupied and rear-area territories require different response strategies. Five directions for restoring the natural ecosystems of territorial communities are systematized: monitoring and assessment, land remediation, restoration of water bodies, restoration of forest and protected ecosystems, and institutional-legal support. The need to integrate environmental priorities into the local post-war development strategies of territorial communities and to secure active public participation in recovery measures is substantiated. The material of this chapter may be used by local self-government bodies in developing environmental-rehabilitation programmes, as well as in the educational process of higher-education institutions in the environmental and geographical fields.

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