

Ways to Restore Ukraine's Environment in the Post-War Period

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Abstract – The environmental crisis in Ukraine caused by the war will have significant consequences for hundreds of years to come and will affect neighboring countries and the world at large. Obviously, it is impossible to return the environment to its pre-war state, but it is possible to activate all scientific potential and human resources to improve the situation and allow ecosystems to gradually rebalance. The purpose of the article is to identify the main directions for overcoming the environmental crisis in Ukraine in the post-war period. The article analyzes the environmental consequences of the war, presents research by Ukrainian and European scholars, and focuses on international cooperation in solving environmental problems. The main environmental challenges, including soil, water, and air pollution, destruction of forests, etc. are discussed. The publication outlines areas of environmental rehabilitation related to innovative technical activities, implementation of foreign experience, public initiative, and an expanded range of environmental education and awareness. Innovative approaches of Ukrainians to combat the environmental crisis related to water, soil and air purification are emphasized. The environmental problems in Ukraine during the war period and plans for environmental restoration in the postwar period are covered in the works of Ukrainian ecologists (T. Denysenko, O. Mudrak, O. Naidenova, S. Rudyshyn and others) and European ecologists (W. Filho, J. Eustachio, D. Pietrzyk-Reeves, J. Carbonell). The article provides a list of Ukrainian NGOs

engaged in environmental protection activities and organizing various environmental public initiatives. Particular attention is paid to the results of a survey of the population of Vinnytsia, Lviv, and Khmelnytsky regions, which showed the readiness of the population to engage in environmental activities. The article focuses on raising the environmental awareness of citizens as a basis for sustainable development of the country. The article emphasizes the need for an integrated approach that combines public policy, research, civic initiatives and international cooperation to effectively restore Ukraine's environment in the postwar period.

Keywords – ecological restoration, ecological consequences of war, sustainable development, nature-based solutions, ecological education, public participation.

I. INTRODUCTION

Around 30% of Ukraine's protected areas (over 1.2 million hectares) have been damaged by the hostilities. According to the Ministry of Environmental Protection and Natural Resources of Ukraine, as of November 2024, 180 million tonnes of carbon dioxide were released into the atmosphere as a result of shelling and forest fires. In addition, about 425,000 hectares of forests are contaminated with mines and unexploded ordnance, making it difficult to restore and use them. Ukraine's

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water resources have also suffered significant damage. Russian shelling destroyed sewage treatment plants and port infrastructure, especially in the Mykolaiv area, causing untreated sewage to enter the sea. Russian tankers sank as a result of the fighting, spilling thousands of tonnes of fuel oil into the Black Sea, polluting more than 60 km of coastline and killing dolphins and other marine animals. The destruction of the Kakhovka dam released more than 90,000 tonnes of heavy metals, which flowed into the Dnipro River and the Black Sea, causing toxic pollution of water and soil. Mines and missile debris in coastal waters pose a danger to marine life and impede navigation, which also hinders scientific research and environmental monitoring. In addition to natural ecosystems, agricultural land has also been severely damaged. Due to explosions, shelling and heavy machinery, the soil lost its fertility. Some fields were rendered unusable for cultivation due to contamination with heavy metals and explosive residues. Experts estimate that restoring the fertility of these lands will take decades and significant investment. Many species of fauna, especially rare and endangered species, were forced to leave their natural habitats. Shelling and explosions have destroyed bird nesting sites and disrupted animal migration routes. Some species of animals living in the steppes and forests have significantly reduced in number. Despite the large-scale destruction, Ukraine has already begun work to restore the natural environment. The government, together with international organisations, is developing programmes to clear mined areas, clean up water resources and restore forests [13].

During the international online conference “The Environmental Consequences of Russian War in Ukraine: Together for the future recovery of the Ukrainian environment” highlighted and analysed the environmental damage caused during the first months of the war, and focused on the territories of the most affected regions – Zaporizhzhia, Dnipro and Kharkiv [4]. The World Wide Fund for Nature (WWF) provides recommendations on how to restore Ukraine's natural resources after the war, focusing on nature-based solutions: developing a national plan for water restoration, investing in artificial forests, implementing nature-based solutions, adapting Ukrainian legislation to European standards, and documenting environmental crimes [5].

Studies by W. Filho, J. Eustachio, M. Fedoruk, T. Lisovska on environmental problems in Ukraine have shown that the detonation of explosives and the movement of heavy military equipment damage the soil structure, contaminate it with heavy metals (Zn, Cu, Pb, Cr, Ni, Cd), which reduces yields by 5-10%, and emissions from military vehicles and explosions increase the level of PM_{2.5}, NO₂ and CO, which exceeds all-Ukrainian healthcare organisation safe standards. This causes respiratory diseases and threatens the

environment. Studies have also highlighted a number of health problems caused by environmental issues, including contaminated water causes intestinal infections, dehydration and exhaustion, toxic substances in the air cause respiratory problems, skin irritation and increase the risk of cancer, heavy metal contamination of soil reduces crop yields, leading to malnutrition and weakened immunity, loss of natural resources and toxic poisoning negatively affect the liver, kidneys and nervous system, explosions cause hearing damage and psychological stress [7].

According to J. Carbonell, Ukraine's environmental problems are the problems of the whole world, and to solve them, it is important to develop environmental nationalism, which combines environmental rhetoric with national interests, which allows for wider public support. Ecological nationalism is based on resource conservation, the use of modern cleaning technologies, thorough environmental education, and broad international cooperation [1]. In his scientific works, D. Pietrzyk-Reeves supports the opinion of J. Carbonell and emphasises environmental activism as the primary way to overcome the environmental crisis. First and foremost, environmental activism is based on environmental education, raising environmental awareness of society, involves performing tasks that are feasible for everyone (sorting garbage, caring for stray animals, planting greenery), then – intensifying technological utilisation and recycling of garbage, developing chemical / biological agents for soil restoration, water and air purification, etc [10].

Organisations such as the United Nations Economic Commission for Europe (UNECE), the United Nations Environment Programme (UNEP) and the Organisation for Economic Co-operation and Development (OECD) have established the Platform for Action for a Green Recovery of Ukraine. This initiative aims to coordinate international efforts to support the country's environmental recovery. The main areas of “green” reconstruction include the application of sustainable procurement principles in the design, selection of materials and construction processes to ensure environmentally friendly and energy-efficient infrastructure; reducing dependence on fossil fuels through the development of renewable energy sources and improving energy efficiency are key elements of the strategy [4].

Ukrainian ecologists (O. Angurets, Y. Bengus, O. Vasylyuk, S. Zhuk, O. Mudrak, V. Parkhomenko, K. Polyanska and others) are actively researching the impact of the war on the environment and documenting the environmental consequences of hostilities. Ukraine identifies environmental issues as one of the priorities in the recovery process. Among the 10 points of the Peace Formula, the eighth is dedicated to environmental safety. In the document, Ukraine emphasises the importance of the international community's support in ensuring

environmental safety and counteracting the environmental consequences of war: environmental damage assessment; accountability for damage; recovery and reconstruction, including the transition to a green economy. Cooperation with international organisations and states is key to effectively responding to the environmental challenges of war, as well as to support Ukraine in its efforts to restore ecosystems and counteract the environmental consequences of war [9]. In her research, K. Belousova argues that it is possible to overcome the environmental crisis by changing the paradigm of thinking (the need to overcome self-centred attitudes towards nature, raising citizens' environmental awareness as a basis for sustainable change); developing "a green economy" and implementing environmental standards; developing science and introducing technological innovations, focusing on the European "green course" and joining European environmental initiatives [8]. T. Denysenko argues that Ukraine's priority is to create a sustainable and ecological environment, to ensure that environmental policy has a cross-cutting impact on all sectors of the economy, to create a modern transparent system of state and environmental control, and to restore the natural environment in the war-torn regions (Luhansk, Donetsk, Kyiv, Chernihiv, and Sumy oblasts) [2].

In February 2024, a High-Level Working Group on the Environmental Consequences of the War was established, comprising Ukrainian and European officials. This group signed the Environmental Pact for Ukraine, which defines strategies for post-war environmental restoration, including demining, environmental restoration, and building a green economy. The main tasks of the pact include demining (detection and disposal of mines and shells in contaminated areas, cleaning soils and water bodies from heavy metals and chemicals, and restoring agricultural land fertility); restoration of the natural environment and biodiversity (cleaning rivers and lakes from pollution and debris, protecting rare species of animals and plants, including many endemic species that live only in Ukraine); building a green economy and sustainable development (establishing renewable energy sources: solar, wind, solar thermal, and support for environmental start-ups and innovative solutions in the field of energy and waste management) [6].

To date, international cooperation in environmental policy has already been tangible, as projects to demine agricultural land in Kherson and Mykolaiv regions have been developed in cooperation with the European External Action Service (EEAS), a project to restore wetlands in the Askania Nova reserve is being implemented with the support of the European Environment Agency (EEA), and the construction of solar power plants in the de-occupied territories of Mykolaiv and Zaporizhzhia regions is being financed in

cooperation with the European Investment Bank (EIB). In addition, the EU candidate status encourages Ukraine to implement environmental reforms and adapt to European environmental standards, which will contribute to sustainable development and economic growth.

The purpose of the article is to identify the main directions of overcoming the environmental crisis in Ukraine in the post-war period.

The purpose of the study is to develop models for overcoming the environmental crisis in Ukraine in the postwar period based on the analysis and systematization of theoretical developments on this issue.

II. MATERIALS AND METHODS

According to the website of the Ministry of Environmental Protection and Natural Resources of Ukraine, 3,750 cases of damage to the natural environment were recorded as a result of the war. In particular: 1622 cases of air pollution, 2912 cases of soil pollution, and 216 cases of water pollution, each of which has numerous negative consequences. The hostilities resulted in the burning of 66,877 hectares of forests and other green spaces, which resulted in the emission of approximately 54,685,316 tonnes of harmful substances into the atmosphere. The combustion of 722,741 tonnes of oil, oil products and gas resulted in additional emissions of 979,526 tonnes, while other sources of pollution caused another 98 tonnes of harmful substances. The area of contaminated land is 18,303,827 m², and the area of contaminated soil is 747,928 m². About 1,693 tonnes of pollutants were released into water bodies, and the weight of foreign objects, materials, waste and other substances in water bodies reached 36,205,704 kg. The Ministry's official data showed a deep environmental crisis in Ukraine, which had significant environmental problems even before the war, including the disposal of radiation emissions from the Chernobyl nuclear power plant, waste sorting and disposal, water treatment, etc [13].

Restoring Ukraine's environment is a complex task that requires a comprehensive approach and the introduction of modern technologies. Several innovative solutions for environmental rehabilitation are currently being developed and implemented:

- *Nature-based solutions.* The United Nations Development Programme (UNDP) in Ukraine implements projects aimed at restoring ecosystems. These solutions include moss modules, rain gardens, living walls, and composters for organic waste, which help clean the air and improve the urban environment.
- *Legislative initiatives.* The Ministry of Environmental Protection and Natural Resources of Ukraine is working on a

framework law “On the Basics of Green Recovery”, which will define key principles and approaches to sustainable recovery of the country in line with European standards.

- *Technological progress.* The use of geoinformation technologies, energy-saving equipment, development of purification filters, etc.
- *Environmental education.* Raising environmental awareness among the population, developing the environmental consciousness of the younger generation, shaping the environmental culture and foresight of Ukrainians [4].

In the course of the study, we used the following methods: theoretical: a method of analysing scientific data to determine the theoretical foundations of the problem, a method of systematising and generalising the theoretical provisions of the problem; empirical: questionnaires and surveys among respondents of higher education institutions on their readiness to participate in environmental activities and implement environmental activism in everyday life.

III. RESULTS AND DISCUSSION

Every day, Ukraine's nature is suffering major harmful effects from the war and requires radical steps to restore and preserve the environment. Ukraine is implementing a number of innovative approaches to clean up and restore the areas affected by the war. For example, it is investing in reforestation and wetland restoration, which helps to sequester carbon, conserve biodiversity and improve water balance. Enterprises are increasing the use of modern bioseptic tanks, which reduce energy consumption and minimise emissions, helping to reduce the negative impact on the environment. Industrial sectors are using the latest methods of wastewater treatment, which contributes to the conservation of water resources and an environmentally friendly economy. Ukraine is developing software for analysing and modelling alternative scenarios for cleaning the environment and developing effective action plans, which helps to optimise wastewater treatment processes. In addition, Ukrainian scientists are working on the development and implementation of biodegradable bottles made from plant components that fully decompose in 18 months, which helps reduce plastic pollution. Ukraine has joined the European LIFE programme, which is an EU financial instrument for environmental protection and financing of environmental and climate measures. Cooperation between different sectors of the economy and integration of environmental principles into all areas of restoration contribute to sustainable development and effective environmental restoration [3].

With the support of the Ministry of Environmental Protection and Natural Resources of Ukraine, the EcoThreat app was developed to provide users with

reliable information about the state of the environment in different regions of Ukraine, including air quality, radiation pollution and water resources. The interactive map shows up-to-date data from monitoring systems and facts of environmental threats caused by Russian aggression [13].

After the outbreak of full-scale war in Ukraine, a number of legislative acts aimed at restoring and protecting the environment were adopted. The Environmental Treaty for Ukraine, developed by the International Working Group, contains 50 recommendations for assessing the environmental impact of the war, compensation for damage and green recovery. In response to the environmental consequences of the war, a roadmap for reforming environmental damage assessment legislation was developed to improve the system of state environmental control and ensure compensation for environmental damage. In addition, the Criminal Code of Ukraine provides for liability for crimes against the environment, in particular under Articles 438 and 441, which relate to violations of the laws and customs of war and ecocide. These legislative initiatives are aimed at ensuring effective restoration and protection of the environment in Ukraine in the post-war period.

The war in Ukraine has also had a significant impact on environmental education, bringing new challenges and tasks. In the context of limited resources and environmental problems, it is important to teach students how to use natural resources and energy rationally, as well as to implement environmentally humane practices in their everyday lives. Ukraine participates in the organisation of environmental competitions, festivals, and outdoor eco-lessons for students. The public is encouraged to participate in various public initiatives.

There are more than 500 environmental non-governmental organisations (NGOs) in Ukraine, active at both the national and local levels. Of these, about 28 have national status and are registered with the Ministry of Justice of Ukraine. These NGOs cover a wide range of environmental issues, including nature conservation, climate change, energy, transport, environmental education and monitoring the environmental impact of war. They actively engage with government agencies, international partners and local communities. NGOs protect the environment, restore natural resources and raise environmental awareness, the most prominent of which are:

- *Ecology. Law. People (EPL)* is a non-governmental organisation that provides legal protection of the environment and monitors violations of environmental legislation.
- *SaveEcoBot* is an online platform and application that provides up-to-date information on the state of the environment in different regions of Ukraine and publishes analytical data.

- *The World Wide Fund for Nature (WWF)* in Ukraine is an international organisation that supports projects to restore natural ecosystems and conserve biodiversity.
- *The Ukrainian Nature Conservation Group (UNCG)* is an association of scientists and activists involved in research and conservation in Ukraine.
- *Global Environment Facility (GEF)* in Ukraine – finances projects to restore the environment and develop sustainable energy.
- *Zero Waste Lviv* is an organisation that promotes the concept of zero waste and waste sorting.
- *National Ecological Centre of Ukraine (NECU)* – promotes environmental policy and advocates for sustainable development.
- *Ukrainian Youth Climate Association (UYCA)* – unites young people to fight climate change and raise environmental awareness.
- *Let's do it Ukraine* is part of an international movement that organises environmental clean-ups and environmental education.
- *EcoClub (Rivne)* – promotes the development of renewable energy sources and energy efficiency in Ukraine.

These organisations deal with the problems of overcoming the environmental crisis, offer many public initiatives for people of different ages, and conduct workshops, trainings, and courses on environmental literacy. It is worth noting that the environmental sector in Ukraine is not limited to NGOs, but also includes government agencies, research institutes, educational institutions, civil society initiatives and international organisations. This demonstrates the diversity and breadth of the environmental movement in the country. However, due to the military operations in Ukraine, their activities are limited, they cannot pursue a broad environmental policy in the frontline areas, i.e. in the epicentre of the environmental threat, and they only try to overcome the consequences of pollution in Ukrainian territories. Although there is a lot of work being done, it is not as effective as it could be, as it does not address the source of the problems, only the consequences.

The above measures show that Ukraine is actively moving towards preserving the natural environment, restoring resources, and stabilising the environmental crisis in the post-war period.

In order to check the readiness of the population for active restoration and environmental protection work in the post-war period. These regions are safe compared to other regions during the war. Lviv region has strong eco-initiatives in waste recycling and energy efficiency. Vinnytsia region has a developed system of waste management and green space. In Khmelnytskyi region, there is a growing interest in renewable energy and agroecology. All three regions are dominated by the agricultural sector. Large-scale farming, the use of

chemicals and changing landscapes create a high demand for environmental solutions: sustainable agronomy, soil protection and ecosystem approaches. That is why these areas were a logical choice for the study. We conducted a survey among 473 respondents in Vinnytsia, Khmelnytskyi and Lviv regions. The questionnaire included 10 key questions. The first of them was “What do you know about the environmental situation in Ukraine during the war period?” Answering this question, 328 (69.3%) respondents gave a short answer: “the ecological situation is terrible”, “Ukraine is in a deep ecological crisis”, “the war has added to the radiation tragedy at the Chernobyl nuclear power plant”, etc.; 145 (30.7%) respondents gave a more detailed answer, including: “large-scale destruction, explosions, fires, water, soil and air pollution – all this has catastrophic consequences for the ecology of Ukraine. The emissions of heavy metals and chemicals from burnt equipment and ammunition are particularly dangerous”. In general, the questionnaires of all respondents showed a deterioration in the environmental situation in Ukraine.

The second question of the questionnaire, “Where do you get information about environmental threats and dangers related to the war?” received the following popular answers: “from the media”, “from social networks – You Tube, Tic-Tok, Facebook”, “from magazines and newspapers”, and the Ukrainian population also learns information from various Telegram channels. In addition, 52 (10.9%) respondents indicated that they follow environmental information through the organisations “Ecology. Law. Human (EPL)” and “SaveEcoBot”, which publish analytics and maps of environmental pollution, as well as monitor reports from the Ministry of Environmental Protection and Natural Resources of Ukraine.

To the third question, “What environmental problems do you consider to be the most pressing after the war?” we offered the following answers: “air and soil pollution”, “destruction of forests and natural ecosystems”, “water pollution”, “garbage and wreckage of military equipment”, “radiation and chemical hazards”, and “their own option”. The respondents' task was to choose the most pressing problem. The answer to the question was almost unambiguous: 419 (88.9%) respondents chose “their own option” and listed the above problems.

To the fourth question, “What consequences of the war have had the greatest impact on nature in your region?” we offered the following answers: “environmental pollution in general”, “loss of biodiversity”, “destruction of natural landscapes”, “deterioration of water resources” and “my own option”. And 328 (69.3%) respondents chose the option “environmental pollution in general”.

The respondents answered the fifth question of the questionnaire “What eco-habits are typical for you?” as follows: 159 (33.6%) – “I have no eco-habits”, 97 (20.5%) – “I sort garbage, try to dispose of waste properly”, 94 (19.9%) – “I save resources: water, electricity, heat”, 43 (9.1%) – “I take care of green spaces”, 38 (8.0%) – “I take care of stray animals”, 27 (5.7%) – “I participate in environmental initiatives of my community”, 15 (3.2%) – “I donate to environmental funds for forest restoration”. The findings showed that a large number of respondents have insufficiently developed environmental awareness and motivation to implement environmental practices in their everyday lives. Respondents mostly interpreted their position as follows: “there are more general issues now”, “nothing will change from me and my actions, let the state deal with it”. However, 314 (66.4%) respondents are engaged in various types of environmental activities, which can be an effective basis for overcoming the ecological crisis.

To the sixth question of the questionnaire “Are you ready to support the policy of environmental activism in Ukraine?” 41 (8.7%) respondents answered that they would most likely not support it due to different life circumstances, 126 (26.6%) respondents said they would definitely support it, despite different life circumstances, and 306 (64.7%) respondents said they would support it if they got to know the conditions in more detail and knew a clear algorithm of actions. Here is a detailed answer from one of the respondents: “I would support the policy of environmental activism, because the state of the environment directly affects our health, the future of our children and the overall quality of life. I have been sorting waste for three years now, but I would gladly support the initiative to green the territory, and I am ready to help restore the environment in the de-occupied territories on a volunteer basis even after the war”.

The seventh question was: “Who should primarily deal with the environmental crisis?” And to this question, 104 (21.9%) respondents answered “the state”, 68 (14.4%) – international organisations, and 301 (63.7%) – “me”. The results demonstrate the active life stance of the population and their desire to change the conditions and quality of life for the better.

The eighth question “What environmental steps should the state take in the process of environmental policy?” received the following answers: “to record military environmental crimes of the Russian Federation”, “to involve international organisations in solving environmental problems”, “to develop a system of environmental education in Ukraine”, “to establish the process of waste disposal and recycling”, “to develop alternative energy”, “to organise more frequent eco-initiatives among the population”, etc.

The ninth question, “How will Ukraine's active environmental policy affect global environmental policy?” received the following answers: “stimulating

international cooperation, which will increase confidence in the country on the world stage and create opportunities for joint projects”, “reducing greenhouse gas emissions and switching to renewable energy sources will help reduce global pollution”, “successful Ukrainian practices in the field of eco-innovation and sustainable development can be used by other countries as an example to follow, which will allow us to popularize our experience”, “protection of natural resources and ecosystems of Ukraine, which is part of the global ecosystem, will have a positive effect on the entire planet”, “reorientation of the economy to environmentally friendly production will increase the competitiveness of Ukrainian goods on the global market”, “raising the level of environmental awareness of the population in Ukraine can become an example for neighboring countries, contributing to global changes in humanity's attitude to nature”.

To the tenth question, “What can you personally do to overcome the environmental crisis in Ukraine?” the respondents answered as follows: “I will separate waste and recycle it”; “I will try to buy less plastic, choose reusable bags, bottles and containers, and avoid disposable items”; “I will save water and electricity, use energy-saving light bulbs and household appliances with a high energy efficiency class”; “I will not litter nature and will participate in cleaning parks, forests and water bodies during environmental campaigns”, “If possible, I will prefer a bicycle or public transport to a car”, “I will support organizations and projects that protect nature”, “I will spread environmental knowledge among friends and acquaintances, because change begins with each of us”, “I will behave responsibly while outdoors, not leave garbage and not harm the environment”.

It is noteworthy that in answering the tenth question, each respondent chose their own way to stabilize the environmental crisis, which they proposed. And while 159 (33.6%) of respondents answered the fifth question that they had no eco-habits, answering the tenth question, respondents were able to analyze their life activities and determine what they could do for the environment on their own. The results show that Ukrainians are aware of the acute environmental crisis, are ready to engage in environmental activities, but need clear paths and civic initiatives to overcome it. In our opinion, an active environmental position will be a step towards overcoming the environmental crisis.

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V. CONCLUSIONS

The war in Ukraine has caused large-scale environmental damage, affecting the quality of air, water and soil, as well as the country's biodiversity. Despite the difficult situation, Ukraine is already implementing innovative approaches to environmental restoration: from nature-based solutions and technological innovations to the development of environmental education and international cooperation.

The results of the survey show that people are aware of the severity of the environmental crisis and are ready to participate in environmental protection activities. Most respondents recognize the need to separate waste, save resources, and support environmental initiatives. However, a significant number of respondents need clear instructions and public projects to intensify their environmental activities.

Synergy between the state, civil society, and international organizations is an important condition for successful recovery. Priorities should include demining, restoring forests and water resources, developing a green economy, and improving the legal framework. Environmental education and awareness-raising will play a key role in shaping a culture of sustainable development.

Thus, the restoration of Ukraine's environment in the postwar period is possible only if a comprehensive approach is taken, with active participation of the population and integration of environmental principles into all spheres of life.

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