RESEARCH AND ENGINEERING INNOVATION PROJECTS OF THE NATIONAL ACADEMY OF SCIENCES OF UKRAINE

https://doi.org/10.15407/scine21.03.029

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IMPACT OF ARMED CONFLICTS ON TERRITORIAL DEVELOPMENT: ASSESSING ENVIRONMENTAL RISKS AND CONSEQUENCES IN UKRAINE

Introduction. *Global risks and armed conflicts are destructive forces that require urgent investigation, particularly regarding their impact on the development of territories affected by war-induced devastation.*

Problem Statement. *The intersection of global risks and military conflicts has long-term consequences, influencing both global stability and local resilience.*

Purpose. *This study has assessed the environmental consequences of war on territorial development and synthesized associated risks through an integrated analytical framework.*

Materials and Methods. *The research employs a deductive approach to monitor global risks and analyze their impact over the past decade. An analytical framework has been applied to assess risks in crisis-affected regions, while the entropy method has been used to evaluate the environmental degradation of Ukraine's regions due to military conflict.*

Results. *Findings have indicated that economic, ecological, and geopolitical risks exerted the greatest influence on society in the past decade, with ecological risks emerging as the most critical. The study has established that the convergence of global risks and military actions disrupts global stability, exacerbating insecurity. Empirical evidence has confirmed that territorial development exhibits varying degrees of environmental vulnerability across Ukraine's regions, with proximity to conflict zones being a key determinant. To restore sustainable development in war-affected areas, comprehensive strategies are required to enhance ecological resilience and strengthen risk management within global environmental governance frameworks.*

Conclusions. *The study's findings have contributed to the development of analytical tools for risk assessment and environmental adaptation, supporting sustainable development initiatives. The practical implications of this research extend to international, national, and regional policy frameworks.*

Keywords: threat, global economic instability, military conflict, sustainable development, environment, entropy.

Citation: Bielikova, N. V. and Levanda, O. M. (2025). Impact of Armed Conflicts on Territorial Development: Assessing Environmental Risks and Consequences in Ukraine. *Sci. innov.*, 21(3), 29—38. https://doi.org/10.15407/scine21.03.029

In the modern world, a key characteristic of the global system is the risk of global socio-economic instability, which is exacerbated by military conflicts. Military actions have catastrophic consequences for populations, states, and the environment [1, 2]. In particular, they violate international law and lead to ecological damage for which aggressor states are responsible [2]. Analyzing the impact of negative events and conditions on territories, economies, populations, and the environment is extremely important for the return of affected countries to normal life and sustainable development [3].

The study focuses on the relevance of discussing global risks and the consequences of war for the environment in the scientific community based on scientific data. Thus, this research aims to identify global risks and the consequences of war for the environment, given the geographical context of Ukraine. It seeks to answer questions about the impact of military conflicts on the ecological situation, as well as their influence on economic stability and the population.

Recent research and publications have focused on the general aspects of risks and conflicts, demonstrating their significant negative consequences. According to the World Economic Forum (WEF), global risk is defined as an uncertain event that may have significant negative consequences for countries and industries over a ten-year period [3]. Global risks are divided into the economic, the ecological, the social, the geopolitical, and the technological risks [4—5]. The economic risks include the destruction of infrastructure and production capacities, which may lead to serious ecological problems due to emissions and spills of harmful substances. The ecological risks encompass serious disruptions such as air, water, and soil pollution, loss of biodiversity, and deforestation. The social risks can arise from mass displacement of people, which can lead to ecosystem destruction, water pollution, and changes in land use. The geopolitical risks may lead to border changes, territorial claims, and expansion, affecting natural resources and the environment. The technological risks include the use of harmful technologies for military purposes, such as chemical, biological, or radiological weapons, which can have a serious impact on the environment.

The purpose of the study is to assess the negative impact of war on the environment of Ukrainian territories and to generalize the accompanying risks using an integrated approach.

The tasks that need to be addressed to achieve the stated research goal include as follows:

(1) Monitoring global risks over the past decade and identifying the main ones. This includes analyzing and evaluating the level of risk on a global scale, given economic, ecological, social, geopolitical, and technological factors.

(2) Studying the impact of conflicts and risks in crisis areas worldwide on affected populations. This involves analytical analysis and comparison of the social and ecological consequences of military actions on the lives and health of residents and their social and economic status at the national level.

(3) Integrated assessment of the negative consequences of war for the environment using the example of Ukrainian territories. This includes analyzing the impact of military conflicts on the environment, such as water loss, water pollution, loss of biodiversity, forests, as well as studying possible ways to restore and protect the environment after military actions.

Global risks identified during the period from 2014 to 2024 encompass current crises that have led to the destabilization of global stability. These crises have had a negative impact on a significant portion of the global economy, population, and environment. Monitoring of data on global risks has identified five main risks that have had the greatest impact on society during this period. The dominant among them is the ecological risk focused on climate change and related environmental issues. The results of the analysis are presented in Table 1. They reflect the global risks over time and their impact on society. It should be noted that the global community cannot eliminate the vulnerabilities that have emerged along-

side the achievements of the 21st century. This visual overview highlights significant points, emphasizing the impact of crises on society during the period under consideration.

The global community is experiencing complex crisis situations, as shown in Table 1. Rapid technological risks acceleration and economic uncertainty have led to dangerous crises such as climate instability and geopolitical tension. These crises are compounded by outbreaks of active combat in various regions of the world, disrupting the global order and contributing to social vulnerability. In 2024, the level of violent conflicts is determined by the Armed Conflict Location & Event Data Project (ACLED) Conflict Index. This index assesses each country based on four indicators: lethality, civilian harm, geographic spread, and armed group fragmentation. National-level conflicts in 2024 are marked in four crisis areas: Myanmar, Palestine, Mexico, and Ukraine. In these countries, conflicts are likely to continue developing next year in interaction with global risks. Among them, Myanmar stands out as a place with the most severe and fragmented violence due to active insurgent groups formed to fight the government. Palestine is associated with the spread of deadly warfare with Israel, while Mexico remains the most dangerous for its citizens due to cartel competition. Ukraine, with a growing violent situation, becomes a target of attacks by Russian forces, causing devastating consequences for civilian areas. It is noteworthy that the violent conflict in Ukraine remains at a stalemate and shows no signs of resolution, with minimal changes including the number of casualties and involved parties. Table 2 demonstrates the intensity of conflict in relation to national-level risks in the four crisis areas as of 2024.

Based on the analysis of data from Table 2, it can be concluded that each of the countries under consideration (Myanmar, Palestine, Mexico, Ukraine) faces unique challenges and problems in

Table 1. T**he Evolving Top-5 Global Risks Landscapes of Impact, 2014—2024**

Position in Top-5 Global Risk	Years					
	2014	2016	2018	2020	2022	2024
1st	Fiscal crises	Failure of climate change mitigation and adaptation	Weapons of mass destruction	Climate action failure	Climate action failure	Extreme weather
2nd	Climate change	Weapons of mass destruction	Extreme weather events	Weapons of mass destruction	Extreme weather	AI-generated misinformation and disinformation
3rd	Water crises	Water crises	Natural disasters	Biodiversity loss	Biodiversity loss	Societal and/or political polarization
4th	Unemployment and underemployment	Large-scale involuntary migration	Failure of climate change mitigation and adaptation	Extreme weather	Social cohesion erosion	Cost-of-living crisis
5th	Critical information infrastructure breakdown	Severe energy price shock	Water crises	Water crises	Livelihood crises	Cyberattacks
Main risk	Economic	Environmental	Geopolitical	Environmental	Environmental	Environmental

Source: compiled by the authors based on [3, 9, 10].

conflict situations. Myanmar, the leader in the conflict index, emerges as country with the most complex situation among the countries examined. Palestine stands out as a place where the conflict affects the entire population, highlighting its profound societal impact. Mexico is characterized by events such as violence against civilians, highlighting the peculiarities of the conflict in this country. Ukraine stands out with a high level of average monthly violent events that may have a significant impact on citizen safety. Among the main risks highlighted are extreme weather, misinformation generated by artificial intelligence, political and social polarization, economic downturn, cost of living crisis, forced migration, interstate armed conflict, and the use of chemical, biological, or nuclear weapons. Overall, the data analysis reveals the diversity of conflicts and their exacerbation, as well as significant social challenges in these regions. Emphasis is placed on the importance of changes in conflict modalities, fragmentation of actors, and state models of political violence for civilians. Considering the fact that Ukraine, compared to the countries under consideration, has the highest frequency of events regarding the intensity of conflict and the geopolitical risk of interstate armed conflict using chemical, biological, or nuclear weapons, this requires focus on key aspects of the Ukrainian conflict, considering the environmental situation, to broaden

Table 2. **Analysis of Crisis Areas: Conflicts, Impact on Population, and Risks, 2024**

Country ranking according to the ACLED Conflict Index (out of 50 countries of the world)	Country	Share of the population affected by the conflict, %	Average monthly value of violent events (for the last 12 months)	The most common type of event	Five main risks
1	Myanmar	68	754	Explosions and remote violence	1. extreme weather; 2. disinformation generated by AI; 3. social and/or political polarization; 4. economic decline; 5. cost of living crisis.
3	Palestine	100	502	Explosions and remote violence	1. extreme weather; 2. disinformation generated by AI; 3. cost of living crisis; 4. cyber-attacks; 5. economic recession.
4	Mexico	42	522	Violence against the civilian population	1. economic decline; 2. state fragility; 3. shortage of energy supply; 4. inequality (wealth, income); 5. illegal economic activities; 6. erosion of social unity.
13	Ukraine	46	3951	Explosions and remote violence	1. interstate armed conflict; 2. forced migration; 3. use of biological, chemical or nuclear weapons; 4. public debt; 5. inflation.

Note: the top 5 risks for Myanmar and Palestine are taken from the macro-region of Southeast Asia and the Middle East due to the lack of data at the national level.

Source: compiled by the authors based on [3, 11–13].

understanding of the situation and make proposals for resolution.

Thus, armed conflicts and wars have a significant negative impact on the environment, not only destroying infrastructure (power plants, waste processing facilities, sewage treatment plants, dams, etc.) but also leading to direct water losses, pollution of water bodies, and loss of biodiversity and forests. Therefore, it is extremely important to conduct continuous monitoring of the negative impact of military actions on the environment of the territories affected by conflict.

To conduct such an assessment, the study used the method of integral convolution of the initial set of partial indicators characterizing various aspects of the sustainable functioning of the environment of the territories.

The starting point for the integral assessment of the impact of war on the territorial development of Ukraine is the indicators of the environmental state (Table 3).

Using the initial data provided in Table 3, we conduct an analysis of indicators such as water intake from natural water bodies, water losses during transportation, water savings through recycling and reuse, discharge of wastewater into surface waters, area of forest loss, forest coverage, etc., distributed across the regions of Ukraine. This approach allows us to form an initial set of partial indicators, which, considering the limitations of state statistical information, provides an understanding of how military actions have affected the state of water resources and forests. The limitation of the study is that similar information for other environmental components (atmospheric air, soils, wastes of various hazard etc.) For the integral assessment, the initial set of partial indicators was standardized based on determining their positive (stimulating) or negative (destimulating) impact on the state of the environment in the territories. Standardization has allowed us to depart from arbitrary units and to obtain values for each partial indicator within the range from 0 to 1. In the next stage, the integral indicator for the system of Ukrainian territories was calculated using the entropy consideration method inherent in this system [14]:

$$I_i = \sum_{j=1}^{n} H_j b_{ij}, i = \overline{1,m}, \quad (1)$$

where I_i is the value of the integral indicator assesses the environmental condition of each region due to the negative impact of war; H_j is the entropy for each partial indicator is derived from the formed initial set; b_{ij} is the quantitative estimate of the j-th feature of the i-th research object; m is the number of research objects; n is the number of features.

Next, we provide integral assessment for each region, visualized using a histogram with logarithmic trend approximation (Figure). This allows for a better understanding of the impact of military actions on various aspects of the country's territorial development and enables the implementation of appropriate measures to minimize their negative consequences and support sustainable development.

Analysis of the logarithmic approximation of the distribution of values of the integral indicator assessing the war's impact on the environment in the system of regions of Ukraine (Figure) allows us to conclude that different regions vary in their vulnerability to military actions. Regions with the lowest indicators, such as Dnipropetrovsk, Odesa, Kyiv, Donetsk, Kharkiv, etc. (0.2131—0.5969), indicate a more vulnerable environmental situation and require immediate measures to protect territories from the negative impact of war. On the other hand, regions with the highest indicators, such as Rivne, Khmelnytskyi, Mykolaiv (0.7784—0.8659), may have more effective measures to preserve the environment and support its stability during the conflict. Regions located in the middle of the spectrum, such as Zhytomyr, Zakarpattya, and Sumy (0.6901—0.6985), reflect an intermediate level of war impact on the environment and may require a comprehensive approach to protecting natural resources and minimizing environmental risks.

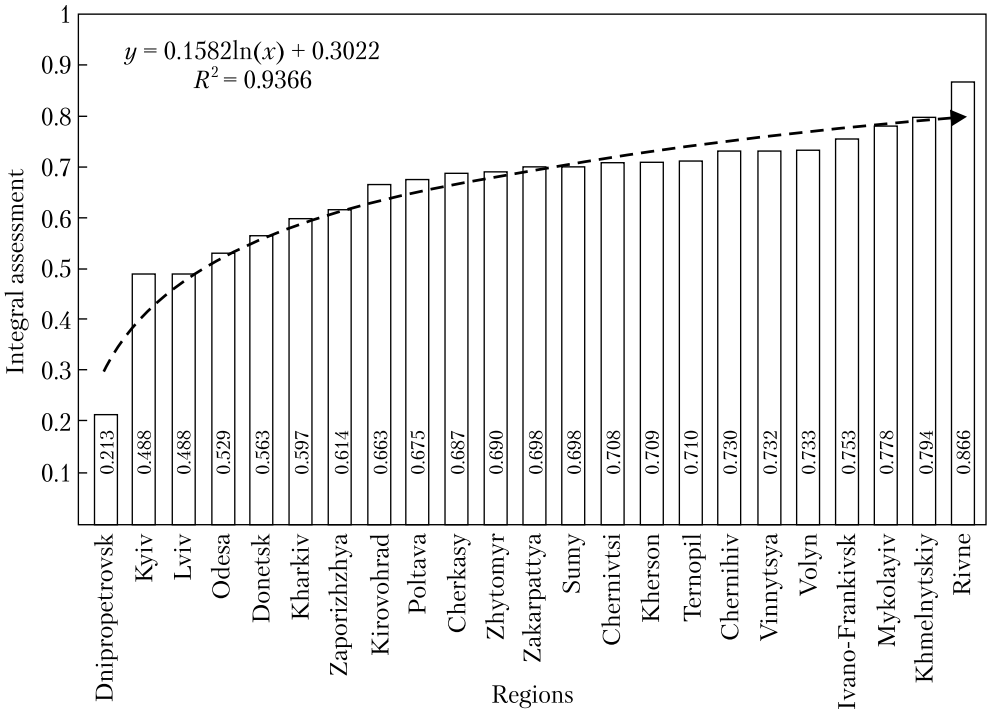
The conclusions drawn are supported by data from periodic monitoring of direct infrastructure

damage and indirect economic losses from destruction due to Russian military aggression against Ukraine, carried out with the support of the American people provided through the United States Agency for International Development (USAID), according to the terms of the grant provided to the Civil Society Organization "Kyiv School of Economics" within the USAID project "Economic Support for Ukraine" [16]. According to this document, Russian military aggression has led to a significant number of hazardous impacts on all components of the environment: atmospheric air, soils and landscapes, surface and groundwater, vegetation, and wildlife. The main environ-

Table 3. **Initial Data for the Integral Assessment of the Impact of War on the Territorial Development of Ukraine. Latest Available Data for 2024**

Regions	Indicators						
	Water withdrawal from natural water bodies by regions, million m^3	Water losses during transportation by regions, million m^3	Economy of water withdrawal due to recycled and repeatable-sequential water-supply by regions, million m^3	Wastewater discharges into surface waters by regions, million m^3	Contaminated wastewaters discharge into surface waters by regions, million m^3	Area of forest plantations death by regions, ha	Forestation area by regions, ha
Vinnytsia	88	13	981	50	1	3	1198
Volyn	42	8	2	23	0	397	3010
Dnipropetrovsk	941	114	2182	540	111	7	390
Donetsk	268	41	1060	199	37	3	0
Zhytomyr	85	10	93	53	1	6582	9716
Zakarpattia	42	7	6	42	4	684	1465
Zaporizhzhia	321	29	650	164	1	0	0
Ivano-Frankivsk	76	10	1415	55	0	407	1720
Kyiv	575	11	80	518	2	148	1606
Kirovohrad	144	10	114	34	17	33	310
Lviv	183	36	385	143	114	395	2404
Mykolaiv	96	14	3458	48	13	899	221
Odesa	668	47	34	93	5	58	53
Poltava	101	14	565	67	23	228	1380
Rivne	105	6	4220	51	4	1916	4647
Sumy	60	9	91	28	15	46	1639
Ternopil	37	3	29	28	2	0	417
Kharkiv	145	69	468	129	3	0	202
Kherson	25	7	15	11	0	0	0
Khmelnytskyi	97	10	2519	35	0	78	978
Cherkasy	149	9	341	69	4	136	955
Chernivtsi	60	13	26	34	1	20	1499
Chernihiv	64	4	31	42	1	317	3018

Source: compiled by the authors based on [14, 15].



Integral assessment of the war impact on the environment by regions of Ukraine with logarithmic approximation of values in the region system, latest available data for 2024

Source: compiled by the authors based on [15].

mental hazard stems from the risks of significant pollution due to damage to industrial enterprises and infrastructure objects from the impact of ammunition or emergency disruption of their operation due to power outages, water supply interruptions, gas supply interruptions, process failures, etc. Combat actions in industrially developed areas in the east and south of Ukraine are particularly dangerous from this perspective. The risks are significantly increased by the fact that military actions have practically paralyzed many aspects of environmental protection activities due to:

- destruction of environmental protection systems in conflict zones;
- complexity or impossibility of updating information on the state of the environment;
- partial or complete cessation of ecosystem services and inability to implement measures to improve the environment, especially in the most affected areas;
- increase in greenhouse gas emissions and overall pollution levels.

Therefore, in order to embark on a sustainable development course and achieve it, the following measures need to be taken:

- implementation of a stable monitoring system of the negative impact of war on the environment of the country's territories, development and implementation of standardized methodologies for assessing direct and indirect damages and losses;
- implementation of environmental protection programs: development and implementation of measures for the reconstruction of industrial processes, rational use of natural resources, and the application of environmentally friendly technologies, including land reclamation, reforestation, water resource purification, disposal of ordnance and mines, as well as measures to prevent further pollution;

- search for and formation of possible financial-economic reserves for immediate improvement of the environment and possible minimization of the negative impact of war on the environment during military operations;
- promotion of renewable energy sources: stimulation of the use of solar, wind, and hydro energy, as well as the development of energy efficiency support programs;
- support for environmental education and conscious consumption: conducting information campaigns, trainings, and lectures on ecology, as well as encouragement of adopting healthy ecological habits in everyday life;
- involvement of the public in nature conservation activities: creation of platforms for dialogue between the public and the authorities, promotion of active citizen participation in addressing environmental problems, and involvement in working groups on environmental issues.

Based on the results of monitoring global risks, as well as considering analytical analysis and comparison of crisis areas in different regions of the world, and taking into account integral assessments of territorial development of Ukraine, the following main conclusions and decisions can be made to support sustainable development:

- strengthening environmental resilience: this may include diplomatic efforts, peacekeeping missions, participation in international agreements and treaties, as well as strengthening national security of Ukraine towards the preservation of water ecosystems, forest resources, and biodiversity;
- enhancing risk management: this includes improving monitoring, analysis, and forecasting of the environment, as well as the development and implementation of effective measures to mitigate the negative consequences of conflicts.

The overall conclusion is that to ensure the sustainable development of Ukraine, it is necessary to implement comprehensive measures to strengthen environmental resilience, reduce geopolitical risks, and protect the environment in conflict situations.

The scientific contribution of the research lies in presenting an assessment tool for the impact of military conflicts on the environment, taking into account the country's territorial development, as well as providing an analytical basis for practical recommendations for risk management and adaptation to environmental challenges in support of sustainable development.

The prospect of further research in this area holds great potential for expanding understanding of the impact of military conflicts on the environment and regional development, aiming to develop strategies for risk management and adaptation to environmental challenges.

FUNDING

The research is conducted within the framework of the topic «Synergetic Effects of Spatial Development Diversification in Ukraine» (No. DR 0124U000046).

ACKNOWLEDGMENTS

We express gratitude to the World Economic Forum international organization for timely publication of statistical data that are available for scientific use, facilitating objective research.

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Received 18.04.2024
Revised 21.07.2024
Accepted 16.08.2024

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ВПЛИВ КОНФЛІКТІВ НА РОЗВИТОК ТЕРИТОРІЙ: АНАЛІЗ РИЗИКІВ І НЕГАТИВНИХ НАСЛІДКІВ ВІЙНИ ДЛЯ ДОВКІЛЛЯ УКРАЇНИ

Вступ. Глобальні ризики та військові конфлікти — деструктивні явища, що потребують негайного дослідження з точки зору їхнього впливу на розвиток територій, які зазнали руйнації.

Проблематика. Негативний вплив глобальних ризиків у поєднанні з військовими конфліктами має тривалі наслідки й охоплює як глобальний, так і локальний рівні.

Мета. Оцінювання негативного впливу війни на довкілля територій та узагальнення ризиків на основі інтегрального підходу.

Матеріали та методи. Застосовано метод дедукції для моніторингу глобальних ризиків і відображення їх у динаміці останнього десятиліття та впливу на суспільство, аналітичний підхід до визначення ризиків у кризових регіонах світу, метод ентропії — для оцінювання негативного впливу війни на стан довкілля регіонів України.

Результати. Виявлено, що за останнє десятиліття найбільший вплив на суспільство справили економічні, екологічні та геополітичні глобальні ризики, серед яких екологічний ризик є домінуючим. Встановлено, що глобальні ризики у поєднанні з військовими діями порушують глобальний порядок, сприяючи загальній незахищеності. Емпірично підтверджено, що територіальний розвиток в межах країни має різну міру вразливості довкілля різних регіонів перед військовими діями залежно від близькості до зони бойових дій. Для відновлення до рівня сталого розвитку постраждалих внаслідок військових конфліктів територій необхідно вживати комплексних заходів щодо зміцнення екологічної стійкості та посилення управління ризиками на всіх рівня управління світового ландшафту.

Висновок. Використання результатів дослідження дозволить розробити аналітичні інструменти для управління ризиками та адаптації до екологічних викликів з метою підтримки сталого розвитку. Практичні результати можуть бути застосовані на міжнародному, державному і регіональному рівнях.

Ключові слова: загроза, глобальна економічна нестабільність, військовий конфлікт, сталий розвиток, довкілля, ентропія.