

ORIGINAL RESEARCH ARTICLE

Armed conflicts and their environmental
impacts: Toward a global legal framework for
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Abstract

In an era marked by intensifying armed conflicts, the protection of ecosystems and natural resources has become an urgent global imperative. This study aims to explore the environmental damage caused by armed conflicts and their prolonged effects on ecosystems and natural resources, highlighting the need for innovative and sustainable legal and policy solutions. The study adopts an analytical approach based on a comprehensive review of scientific literature and international documents on the impacts of armed conflicts on ecosystems. It integrates quantitative and qualitative data from reliable sources, such as the United Nations Environment Programme, to identify legal gaps and propose innovative solutions that enhance sustainability and international cooperation. The study reveals that despite the presence of international agreements, significant gaps remain in legal enforcement and cooperation between states and United Nations agencies, thereby limiting the effectiveness of environmental protection during armed conflicts. It also identifies mechanisms for the sustainable rehabilitation of affected areas. This study proposes an innovative global legal framework and practical mechanisms to integrate international law with environmental sciences, ensuring long-term sustainability of natural resources during and after armed conflicts.

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1. Introduction

The environmental damage resulting from armed conflicts is a critical and urgent issue that threatens environmental sustainability and profoundly impacts human life both now and in the future.¹ As armed conflicts escalate, the environment faces multiple risks—ranging from pollution caused by toxic chemicals and military materials to the destruction of natural habitats and the depletion of essential resources, such as freshwater. These damages not only affect the period of conflict itself but also extend

to future generations, leading to long-term negative effects that cause biodiversity degradation and environmental security threats.²

Despite the existence of numerous international treaties and agreements aimed at minimizing the environmental damage caused by armed conflicts, including the First Additional Protocol to the Geneva Conventions of 1977, the actual implementation of these treaties faces several prominent challenges—such as weak coordination and international cooperation, inadequate enforcement mechanisms, and legal gaps—that allow states and military groups to act in ways that may exacerbate these damages. One of the main reasons hindering the effectiveness of these agreements is the absence of a comprehensive and binding legal framework that sets clear and mandatory standards for environmental protection during armed conflicts.

In the absence of such an integrated legal framework, a fundamental and critical question arises: How can a global legal framework be established to ensure the protection of ecosystems during armed conflicts and to reduce damage that may continue affecting the environment for decades after the conflict ends? This question is not merely an academic or theoretical matter but an urgent necessity to ensure a sustainable and secure environmental future for generations to come.³

This study aims to explore the environmental damage associated with armed conflicts by reviewing the direct and indirect impacts on the environment and communities, focusing on understanding the effectiveness of current legal frameworks. Additionally, the study seeks to offer international legal proposals that enhance military obligations to protect the environment by reviewing and analyzing current international practices and experiences in this field using an integrated legal methodology that includes documentary research and comparative analysis. The challenges and potential opportunities for developing a global legal framework that sets clear standards and enhances international cooperation to mitigate environmental damage and ensure the sustainability of natural resources during armed conflicts will also be explored.

2. Environmental costs of war: Impacts on natural habitats

Armed conflicts result in widespread destruction of natural habitats⁴, as the use of munitions and toxic chemicals leads to long-term environmental pollution,⁵ posing a threat to biodiversity and creating lasting environmental harm.⁶

The 2023 United Nations reports⁷ indicate that the

Russian–Ukrainian war, which erupted in 2022, caused severe pollution in vast areas of Ukraine’s agricultural land, with an estimated cleanup cost of USD 34.6 billion and a timeframe extending for a decade.⁷ These patterns of destruction have been repeated in past wars. The Vietnam War (1954–1976) saw extensive devastation of rural areas, with military operations involving bombings of forests and farmlands, and the use of mechanical and chemical methods to destroy crops. Among the chemicals used, “Agent Orange”—a compound containing the toxic dioxin, which is carcinogenic and causes severe genetic and health disorders in living organisms—was the most prevalent and impactful.⁸ Military actions turned biodiversity-rich forests into barren lands, destroyed 70% of coconut trees and 60% of rubber plantations, and led to the loss of 110,000 hectares of forest and 150,000 hectares of mangrove forests. These impacts contributed to the extinction of various plant and animal species, including the Asian elephant, Javan rhinoceros, and tigers.⁹ Additionally, the use of “Agent Orange” contaminated the environment with dioxin compounds, severely damaging biodiversity, significantly impacting agricultural resources, and creating complex challenges for food security.¹⁰

The ongoing war in Syria since 2011 has also led to significant losses in forest cover, with the loss of approximately 9.26% of the country’s forests due to increased human activities, such as illegal logging, land conversion for agriculture, and deliberate fires. This degradation complicates efforts to restore ecosystems and threatens the sustainability of biodiversity, especially in vital areas such as coastal mountain ranges, Mount Al-Druze, and the Golan Heights.¹¹

Despite ongoing initiatives for reforestation and the removal of unexploded ordnance, toxic substances continue to pose a long-term risk to natural habitats.¹² These examples underscore the urgent need for comprehensive and sustainable strategies for environmental restoration in conflict-affected areas. Simultaneously, peace presents a pivotal opportunity to initiate these efforts and achieve ecological recovery.^{13,14}

3. The contribution of military activities to climate change

Military activities are a major source of harmful emissions¹⁵, with the global military carbon footprint estimated at around 2,750 million tons of carbon dioxide (CO₂) equivalent annually, representing 5.5% of total global emissions¹⁶, according to the 2022 report produced in collaboration with the Conflict and Environment Observatory.¹⁷ If considered as a single entity, the world’s armed forces would rank fourth globally in emissions,

after China, the United States, and India, surpassing major nations such as Russia and Japan (Figure 1).¹⁷

Despite these alarming figures, international environmental agreements, such as the Kyoto Protocol and the Paris Agreement, have not included military activities within their pollution reduction strategies, highlighting a legal gap that needs to be addressed. Military operations contribute to increased greenhouse gas emissions, including CO₂ and methane (CH₄), through the burning of fossil fuels and the destruction of natural habitats.¹⁷

Furthermore, explosions and infrastructure destruction release toxic pollutants that amplify negative impacts on both the environment and human health.¹⁸ Previous studies indicate that these effects are not limited to wars but also extend to routine military training, posing a threat to the sustainability of ecosystems.¹⁹

To make significant progress in reducing these emissions, military activities need to be integrated into global environmental policy frameworks. This can be achieved by amending international agreements to include mandatory disclosure of military emissions and encouraging the adoption of military systems powered by clean energy instead of fossil fuels. Strengthening international cooperation in this area is a crucial step toward achieving global environmental goals and ensuring the sustainability of ecosystems.

4. Indirect environmental impacts of military operations on natural habitats

Beyond conventional military operations on land, sea, and air, the militarization of space has emerged as an indirect yet significant environmental challenge to natural habitats through a range of ecological impacts.²⁰ The production of space debris, often resulting from the use of anti-satellite weapons²¹, leads to continuous collisions that disrupt the Earth observation systems crucial for environmental protection and natural resource management. Additionally, military activities in space pose a threat to satellites used for climate monitoring, forest tracking, and water resource management, undermining global efforts to support ecosystem monitoring and management.^{22,23}

Furthermore, explosions and other military operations can lead to changes in atmospheric dynamics and the release of pollutants that affect Earth's climate and its ecosystems.²⁴

While the 1967 Outer Space Treaty provides a legal framework for regulating space activities and prohibits placing weapons of mass destruction in orbit or on celestial bodies²⁵, it lacks explicit provisions to prevent the development or use of anti-satellite weapons. This absence places such activities in a legal gray area, highlighting the need to update the treaty to address these challenges and ensure the peaceful use of space.⁵

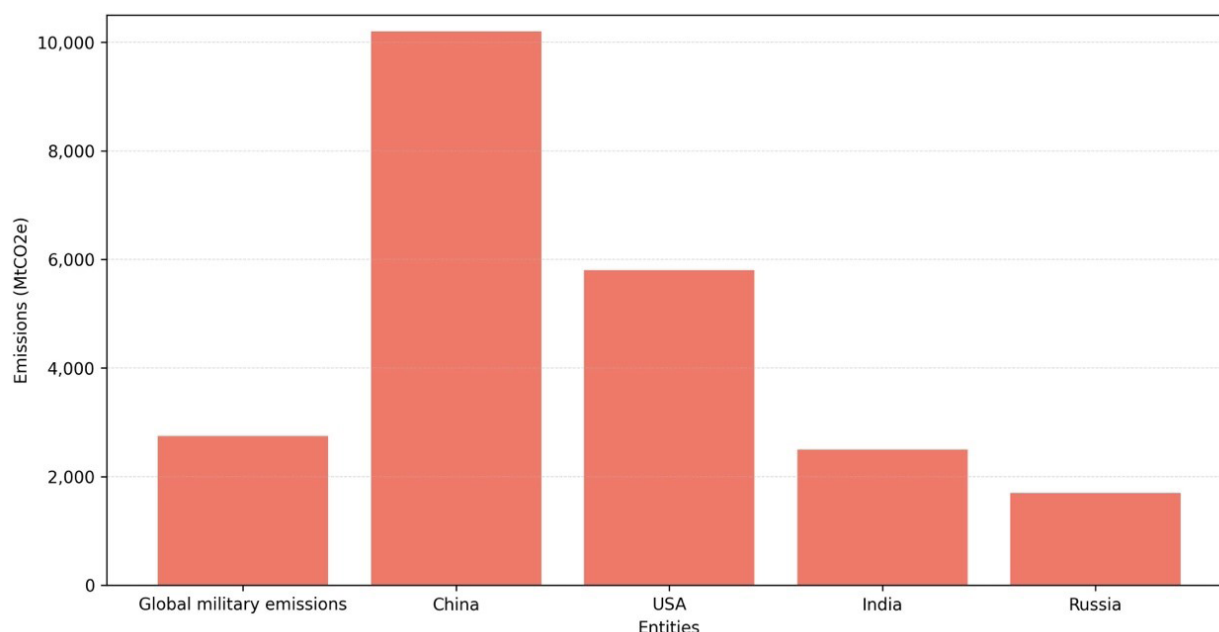


Figure 1. Comparative carbon footprint of the global military and major emitting countries
Abbreviation: MtCO₂e: Million metric tons of carbon dioxide equivalent.

Current international laws struggle with interpreting cases that justify the use of force in space. The absence of a precise definition for “armed attack” in the context of satellites, including cyberattacks or jamming operations, raises questions about whether these actions would warrant a military response under Article 51 of the United Nations Charter.²⁶

Additionally, dual-use technologies that serve both civilian and military purposes complicate the process of determining whether the actions taken fall within the scope of an “armed attack,” making it difficult to distinguish between legitimate and illegitimate targets in armed conflicts.

5. The impact of disrupting international cooperation on environmental protection during armed conflicts

Despite advancements in international environmental law,²⁷ these laws face significant challenges during armed conflicts.²⁸ Notable agreements—such as the First Additional Protocol to the Geneva Conventions of 1977, which prohibits causing widespread, long-term, and severe environmental damage—still face practical enforcement difficulties. One of the primary challenges is demonstrating the extent and magnitude of environmental harm.²⁹

Additionally, the 1993 Chemical Weapons Convention aims to prevent the harmful use of chemicals in conflicts; however, it has limitations, as it does not cover conventional weapons that may contain toxic substances.³⁰ Reports from the United Nations in 2023 indicate that there are over 170 armed conflicts worldwide.³¹

The conflicts in Syria and Ukraine,³² for instance, have shown devastating effects on natural habitats³³, underscoring the urgent need to develop international cooperation mechanisms that integrate environmental protection with peace strategies to ensure the sustainability of natural resources.³⁴ These mechanisms should include a comprehensive legal framework for safeguarding natural habitats and promoting sustainable development in conflict-affected areas.³⁵

6. Challenges in implementing current environmental laws during conflicts

6.1. Lack of resources for monitoring violations

The enforcement of environmental protection during armed conflicts faces significant challenges, particularly due to limited financial, technical, and institutional resources available for monitoring and documenting violations. In such contexts, state priorities are often redirected toward immediate security and defense needs,

resulting in environmental concerns being deprioritized. Consequently, inadequate resources are allocated to address environmental harm, including pollution arising from the use of weapons and the destruction of natural habitats.²¹

The International Committee of the Red Cross guidelines on environmental protection during armed conflicts emphasize the importance of allocating sufficient resources for effective monitoring and enforcement, while acknowledging that states frequently lack the capacity to do so during wartime.²¹ Similarly, the 1977 First Additional Protocol to the Geneva Conventions prohibits attacks that cause widespread, long-term, and severe damage to the natural environment; however, the practical enforcement of this prohibition depends on robust monitoring and documentation mechanisms, which are often constrained in conflict situations.³⁶

The tension between short-term wartime imperatives and long-term environmental obligations underscores the need for adaptive, realistic strategies to enhance compliance with international environmental standards under conditions of armed conflict.

6.2. Difficulty in accessing affected areas during wars

During armed conflicts, security restrictions and ongoing attacks impede both international and local organizations from accessing areas that have suffered significant environmental damage. Additionally, conflicting parties may intentionally block access to these areas, resulting in a substantial lack of accurate information on the extent and nature of the damage.³⁷

The 1954 Convention for the Protection of Cultural Property in the Event of Armed Conflict³⁶ emphasizes the importance of safeguarding environmentally significant sites during conflicts. However, it does not provide clear mechanisms to ensure access to these areas. Reports from the United Nations Environment Programme during conflicts in Iraq and Syria have highlighted that environmentally affected areas were inaccessible due to ongoing warfare, hindering environmental assessments and damage remediation efforts.³⁸

6.3. Absence of effective mechanisms for international accountability

Despite the existence of international agreements aimed at holding parties accountable for violating environmental laws during conflicts²⁷, these mechanisms often remain inactive due to a lack of political will and legal complexities.³⁹ For example, the 1998 Rome Statute of the International Criminal Court recognizes war crimes that

include causing significant environmental damage, yet, to date, no individual has been prosecuted by the ICC specifically for environmental war crimes.⁵ Similarly, the First Geneva Protocol acknowledges the protection of the environment during armed conflicts but does not provide clear enforcement mechanisms, making compliance dependent on good faith rather than being applied through binding legal tools.⁴⁰ A report by the United Nations Environment Programme on the conflict in Kosovo in 1999 emphasized the absence of effective international accountability mechanisms to address environmental damage caused by armed conflicts.⁴⁰

These challenges can be overcome by leveraging modern technology such as satellites, eco-friendly weapons, and artificial intelligence (AI). These innovative tools provide effective solutions for reducing environmental damage from armed conflicts, as they enable accurate monitoring, improve assessment of damage, and facilitate prediction of future impacts, thereby enhancing environmental restoration efforts in affected areas.⁴¹

Therefore, while states bear the primary responsibility for implementation, many countries are not parties to the Rome Statute of the International Criminal Court, which significantly limits the Court's jurisdiction and its capacity to serve as a universal enforcement mechanism. Consequently, there is a critical need to strengthen the role of the United Nations and its specialized agencies in monitoring and addressing environmental violations during conflicts. Drawing on instructive precedents from international frameworks established for anti-personnel landmine monitoring, the development and application of innovative United Nations-led mechanisms—such as enhanced reporting mandates, coordinated field assessments, and satellite-based surveillance—could substantially improve compliance and accountability in situations where traditional legal enforcement is fragmented or unavailable.

7. The global framework for ecosystem restoration: A study of a selected initiative

International initiatives for ecosystem restoration are cornerstones for evaluating and developing effective strategies to address the environmental impacts on natural habitats in regions affected by armed conflicts. Among these initiatives, pioneering models provide valuable lessons for ecosystem restoration and sustainability enhancement⁴²:

(a) The Bonn Challenge

The Bonn Challenge is an ambitious global environmental initiative aiming to restore 350 million hectares of degraded land by 2030⁴³, making it one of the largest global reforestation and ecosystem restoration

efforts.⁴⁴ Since its launch in 2011, the initiative has made significant progress, having restored 150 million hectares of degraded land by 2017, and currently involves over 70 participants from 60 countries in the restoration of 210 million hectares.²⁵ This initiative focuses on boosting biodiversity and reducing carbon emissions that drive climate change, contributing to the achievement of global environmental sustainability goals.⁴⁵

However, despite this progress, the Bonn Challenge faces ongoing challenges, particularly due to the impact of armed conflicts. Studies have shown that armed conflicts lead to the destruction of natural habitats and the degradation of ecosystems in affected regions, hindering ecological restoration efforts and exacerbating desertification.

This ongoing destruction not only delays the implementation of the initiative but also complicates the achievement of global environmental goals at a time when the need for ecosystem restoration to combat climate change is increasing. Moreover, conflicts contribute to widespread environmental damage, requiring significant investment for rehabilitation.⁴⁶

However, these investments remain limited due to insufficient funding to cover conflict-related damages.⁴⁷ Therefore, ensuring the success of global environmental efforts requires the introduction of international legal measures that promote environmental compliance during conflicts, alongside the activation of effective international cooperation to preserve biodiversity and protect ecosystems during crises.⁴⁸

(b) The Global Biodiversity Framework

The Global Biodiversity Framework, established by the United Nations, aims to achieve long-term environmental sustainability³⁷ by rehabilitating natural habitats for threatened species and ensuring the sustainability of vital resources.⁴⁹ Since its inception, its goals have been incorporated into national and international policies, contributing to improved biodiversity in certain regions and the restoration of habitats affected by human activities.⁵⁰

However, armed conflicts pose a significant threat to the success of this framework, as they cause the destruction of natural habitats and exacerbate ecosystem degradation through overuse of land and resources, as well as pollution from weapons and chemicals.⁵¹ Wars also impede conservation efforts, as nature reserves become susceptible to attacks or destruction⁵², thereby hindering the restoration of threatened species.

Studies in conflict zones have shown that Syria has witnessed significant forest destruction due to ongoing

conflict, resulting in a substantial decline in biodiversity.⁵³ In South Sudan, while some natural habitats have survived the impacts of war, human activities related to conflict, such as poaching, have contributed to the decline in elephant and rhinoceros populations, with poaching increasing significantly in conflict-affected areas.⁵⁴ In Afghanistan, wars have destroyed agricultural lands and forests, harming threatened species such as the Persian leopard. These challenges are further exacerbated by the breakdown of international cooperation in these regions, hindering the implementation of effective environmental policies.⁵⁵

Integrating biodiversity conservation policies into conflict resolution strategies, together with strengthening international cooperation, is essential for ensuring the long-term sustainability of ecosystems and protecting natural habitats from the destructive impacts of armed conflicts.

8. Methodology

This study adopts a qualitative doctrinal legal methodology, supplemented by a structured analytical review of scientific literature and international documents on the environmental impacts of armed conflicts. Particular attention was given to cooperative international efforts aimed at ecosystem restoration and environmental sustainability.

The methodology incorporates selected examples to illustrate the effects of armed conflicts on ecosystems and natural habitats, clarifying the scale and scope of the resulting damage. The research draws on the analysis of both qualitative and quantitative data from reliable sources, including reports issued by international environmental organizations and peer-reviewed studies, to support the findings and inform practical recommendations for future environmental policies. This approach further seeks to identify existing legal gaps and propose solutions that promote ecosystem sustainability within an international collaborative framework.

9. Results

Modern technology plays a pivotal role in mitigating environmental damage caused by armed conflicts. Tools such as satellites, eco-friendly weapons, and AI provide innovative and effective methods for monitoring environmental harm. These technologies enhance the ability to assess current damage and predict future impacts, thereby supporting targeted ecological restoration efforts in affected areas.

Despite these technological advances, the lack of accurate and reliable environmental data remains a

significant challenge. Many conflict-affected regions suffer from inadequate monitoring, which limits the ability to make informed decisions during rehabilitation processes. This deficiency not only hinders timely intervention but also delays the implementation of effective environmental policies.

Strengthening international cooperation is essential for overcoming these challenges. Collaboration between countries and international organizations facilitates the sharing of knowledge, expertise, and resources. Such partnerships enhance environmental monitoring and support the development of proactive strategies aimed at minimizing the adverse impacts of conflicts on ecosystems.

Integrating environmental issues into peacebuilding and reconstruction efforts is also critical. Considering environmental protection within these processes can promote sustainability and strengthen long-term social and economic stability. Moreover, this integration reduces the risk of future conflicts related to the exploitation or degradation of natural resources.

Restoration of ecosystems in post-conflict areas requires innovative strategies tailored to the specific environmental context. Approaches such as reforestation, the restoration of water resources, and the adoption of sustainable agricultural practices contribute significantly to both ecological recovery and social resilience. These strategies are fundamental to supporting sustainable development in affected regions.

Finally, establishing a robust legal framework dedicated to environmental protection and sustainable practices in post-conflict settings is essential. Such frameworks provide necessary support for recovery initiatives and help ensure long-lasting environmental and societal stability.

10. Discussion: Analysis of results and application prospects

This study addresses the environmental damage resulting from armed conflicts and proposes a global legal framework for environmental protection. The findings highlight the role of modern technology, challenges associated with the lack of precise environmental data, the importance of international cooperation, and the necessity of integrating environmental considerations into peace processes and ecosystem restoration.

10.1. The role of modern technology in mitigating environmental damage

The results indicate that advanced technologies, such as satellites, are vital tools for monitoring environmental damage caused by conflicts. These technologies provide

real-time data, facilitating swift and effective responses. Studies have underscored the importance of using medium-resolution satellite remote sensing for monitoring environmental degradation.⁵⁶ These technologies are a practical alternative in high-risk areas, bridging gaps in field data collection. In conflicts like those in Syria and Ukraine, aggregated satellite data has enabled accurate environmental assessments and supported emergency responses.⁵⁷

10.2. Challenges related to the lack of precise environmental data

Despite technological advancements, the absence of precise environmental data remains a major obstacle to assessing damage. Disparities in data from different sources complicate environmental analysis. Polukarov *et al.*⁵⁸ have shown that conflicting estimates, as seen in Ukraine, hinder the formulation of long-term environmental recovery plans. Conflicts destroy environmental resources and infrastructure, making it increasingly difficult to gather comprehensive and integrated data.

10.3. Strengthening international cooperation

The findings illustrate that international cooperation is a key factor in addressing environmental challenges. The global nature of environmental issues necessitates concerted efforts between nations and environmental organizations. Ajewumi *et al.*⁵⁹ indicated that technology transfer and international funding enhance the international community's capacity to respond to environmental damage. This cooperation empowers countries to mitigate the negative impacts of conflicts on the environment and supports the sustainability of environmental initiatives.

10.4. Integrating environmental issues into peace processes and reconstruction

Integrating environmental issues into peace processes and reconstruction is crucial for ensuring long-term environmental development. Incorporating environmental considerations into peace agreements fosters political and social stability. Stahn *et al.*⁶⁰ noted that rebuilding ecosystems directly contributes to sustainable development in affected regions. However, there is a need for a legal framework obligating conflicting parties to respect environmental rights during and after conflicts, ensuring continuity in environmental responses.⁶⁰

10.5. Ecosystem restoration

Ecosystem restoration strategies require innovative solutions to support environmental sustainability. Shumilova *et al.*⁶¹ highlighted that reforestation and water resource restoration are vital for achieving long-term

ecological balance. Sustainable agriculture also contributes to environmental and social stability, making it a core component of reconstruction plans.

These results reveal an urgent need for comprehensive and integrated strategies that combine modern technology, international cooperation, and legal frameworks to ensure environmental protection during and after armed conflicts. Adopting these proposals not only safeguards environmental resources but also enhances the stability of affected communities and lays the foundation for lasting peace.

10.6. Innovative legal framework for environmental protection in armed conflicts

Amid the environmental challenges arising from armed conflicts, which result in ecosystem degradation and the depletion of natural resources, the development of an effective and adaptable legal framework is necessary. Rather than aiming to ensure full environmental protection, the proposed framework focuses on mitigating environmental harm, enhancing accountability, and supporting recovery efforts during and after armed conflicts. It reflects a legal approach that aligns global environmental principles with practical implementation mechanisms capable of adapting to rapidly changing conditions of conflict settings.

10.6.1. Core principles of the legal framework

- (a) Commitment to the rights of nature and sustainable development

The legal framework should include principles that emphasize that environmental protection is a fundamental right for present and future generations, ensuring the sustainability of natural habitats as part of post-conflict strategies. This commitment necessitates legislation that promotes biodiversity and integrates ecosystem rehabilitation into peacebuilding and development efforts.

- (b) Flexibility and adaptability to changing conditions

The legal framework must be flexible and capable of adapting to rapidly changing environmental conditions, ensuring effectiveness in diverse and dynamic conflict scenarios.

- (c) Promotion of multilateral cooperation

Collaboration between affected states should be facilitated through the establishment of international and regional cooperation platforms involving the states affected, international organizations, and local partners.

- (d) Reliance on modern technology

Leveraging technologies such as AI, remote sensing, and geographic information systems is essential for accurately monitoring and documenting environmental damage,

thereby supporting effective response and ecosystem rehabilitation.

(e) Accountability and responsibility

Developing clear legal mechanisms for holding parties responsible for environmental damage is critical. Rehabilitation of affected areas should be integrated into sanctions to deter future violations and reinforce the commitment to environmental protection.

10.6.2. Significance of the framework in the international context

The proposed framework aligns with the fundamental principles of international agreements and initiatives, enhancing its effectiveness in protecting the environment during armed conflicts. Key international principles incorporated into the framework include:

- (i) The Geneva Conventions: Emphasize the protection of civilians and the environment during conflicts.² The framework supports this protection by ensuring accountability for parties responsible for environmental damage.
- (ii) Convention on Biological Diversity: Aims to conserve and sustain biodiversity. The framework supports this through ecosystem rehabilitation strategies and sustainable management practices.
- (iii) Outer Space Treaty: Aligns with its objectives by advocating for an update to ensure peaceful and sustainable space activities, contributing indirectly to environmental preservation.²⁵
- (iv) The Paris Agreement: The framework contributes to emission reduction and enhanced monitoring of environmental damage from conflicts, aligning with climate action goals.⁶²
- (v) International initiatives: Examples include the Bonn Challenge and the 2022 Kunming–Montreal Global Biodiversity Framework⁴⁴, through which the framework supports ecosystem restoration and strengthens international cooperation.¹⁷

The integration of these principles into an innovative legal system enables effective responses to environmental damage, contributing to the stability of affected communities, supporting sustainable development, and protecting the planet for future generations.

11. Challenges

Despite progress and the recommendations proposed, several challenges may hinder the implementation of environmental strategies in conflict areas. These challenges include insufficient funding, limited international support for environmental initiatives, political instability in affected regions, and security threats that may impede access for

environmental teams. Addressing these obstacles requires coordinated international and local efforts to ensure the necessary support and the sustainability of environmental implementation in conflict environments.

12. Constraints

This study presents several key considerations that may limit the full application of its findings. First, data related to environmental damage in conflict areas remains limited or inaccessible due to difficulties in reaching these regions during or after conflicts, which negatively impacts the accuracy of real-time environmental assessments. Second, efforts to rehabilitate damaged ecosystems require substantial financial resources, and some countries may struggle to secure the necessary funding, limiting the effective implementation of the proposed strategies.

Furthermore, unstable security conditions in conflict areas can disrupt long-term environmental projects, complicating the implementation of environmental reform initiatives. Additionally, some countries may lack political will or sufficient international cooperation to adopt comprehensive strategies for environmental rehabilitation, reducing the effectiveness of efforts and delaying implementation.

The absence of effective legal frameworks in some countries may also contribute to gaps in addressing environmental impacts, leaving legislation insufficient to ensure the sustainability of rehabilitation processes. These constraints highlight the fundamental challenges in applying the study's recommendations, emphasizing the importance of organized international support, multilateral cooperation, and strengthened legal frameworks with sustainable financing to achieve effective ecosystem restoration.

13. Implications of the study

The findings of this study enhance understanding of ecosystem restoration in areas affected by armed conflicts by offering structured insights relevant to the development of sustainable environmental policies aligned with global environmental objectives. These findings address both opportunities for environmental rehabilitation and the legal and institutional challenges that affect implementation in conflict and post-conflict contexts.

Consistent with Dienelt's⁴⁶ analysis of the limitations of existing legal frameworks during armed conflicts, the present study highlights structural shortcomings in enforcement, coordination, and compliance that constrain environmental recovery efforts. Accordingly, the results may inform environmental experts and practitioners on practices and technologies that can be integrated

into environmental reform processes, while considering prevailing legal and practical constraints.

In addition, the study provides a reference for researchers and specialists in environmental governance and conflict management by supporting initiatives aimed at biodiversity restoration and ecological balance in affected regions. The recommendations emphasize the need to strengthen international cooperation and to develop adaptable legal frameworks capable of addressing the complexities associated with armed conflicts, thereby supporting coordinated environmental rehabilitation efforts.

The study also provides guidance for communities affected by conflicts seeking to restore their ecosystems. It emphasizes the adoption of comprehensive policies based on sustainable rehabilitation strategies, such as sustainable agriculture and reforestation strategies, while acknowledging challenges related to limited resources, political instability, and fragmented legal frameworks. In this context, the study highlights the role of cooperation between governments, non-governmental organizations, and research institutions, as well as the importance of legal and regulatory frameworks in supporting habitat restoration and reducing environmental pollution, contributing to environmental recovery in conflict-affected areas.

14. Recommendations

The following recommendations are proposed:

- (i) The development of a comprehensive and flexible global legislative framework that addresses the challenges of armed conflicts, ensuring the protection of affected ecosystems while remaining adaptable to changing conflict conditions.
- (ii) Strengthening international cooperation with non-governmental organizations and research institutions to support environmental rehabilitation through knowledge exchange and the provision of financial and technical assistance to resource-limited areas.
- (iii) Integrating modern technology into environmental monitoring to enhance ecosystem restoration tracking and improve the effectiveness of rehabilitation efforts in conflict-affected regions.
- (iv) Implementing sustainable rehabilitation strategies, such as reforestation and sustainable agriculture, to promote biodiversity and restore ecological balance in conflict-affected areas.

15. Conclusion

This study highlights that armed conflicts result in severe environmental impacts that significantly affect ecosystems,

threaten biodiversity sustainability, and hinder sustainable development efforts. However, the study provides valuable insights into ecosystem restoration through sustainable rehabilitation strategies incorporating modern technologies and effective environmental practices. It emphasizes the need for a comprehensive and flexible legal framework that enhances international cooperation and responds to the unique environmental challenges in conflict areas.

The study also highlights the importance of integrating modern technology into environmental damage monitoring and assessment, as well as encouraging local communities to adopt sustainable practices such as reforestation and sustainable agriculture. Despite challenges, such as data scarcity and unstable security conditions, the recommendations remain an essential guide for advancing effective and sustainable ecosystem restoration. The international community must collaborate to enhance the implementation of these strategies and raise environmental awareness at both local and global levels to ensure environmental protection during armed conflicts.

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Conflict of interest

The authors declare that they have no conflicting interests.

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