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THE DEVELOPMENT OF THE CONCEPT OF "ENVIRONMENTAL SECURITY" IN THE CONTEXT OF SPACE ACTIVITY REGULATION

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РАЗВИТИЕ ПОНЯТИЯ «ЭКОЛОГИЧЕСКАЯ БЕЗОПАСНОСТЬ» В КОНТЕКСТЕ РЕГУЛИРОВАНИЯ КОСМИЧЕСКОЙ ДЕЯТЕЛЬНОСТИ

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Abstract. The rapid expansion of space activities, including the deployment of satellites, the commercialization of space, and the potential militarization of outer space, has raised serious concerns about the long-term sustainability and environmental safety of outer space. This article explores the evolution of the concept of "environmental security" as applied to the regulation of space activities in international law. The paper examines how current legal frameworks, including the 1967 Outer Space Treaty and subsequent UN resolutions, address the ecological risks posed by space debris, nuclear-powered spacecraft, and military experiments in orbit. The study argues for the need to redefine and expand environmental security to encompass outer space, proposing legal and institutional mechanisms to mitigate the dual threats of environmental degradation and militarization. Emphasis is placed on the integration of environmental principles into space law to ensure the preservation of space as a global common good for future generations.

Аннотация. Стремительное расширение космической деятельности, включая запуск спутников, коммерциализацию космоса и потенциальную милитаризацию космического пространства, вызвало серьёзные опасения по поводу долгосрочной устойчивости и экологической безопасности космического пространства. В данной статье рассматривается эволюция концепции «экологической безопасности» применительно к регулированию космической деятельности в международном праве. В статье рассматривается, как действующие правовые рамки, включая Договор о космосе 1967 года и последующие резолюции ООН, позволяют бороться с экологическими рисками, связанными с космическим мусором, космическими аппаратами с ядерными энергетическими установками и военными экспериментами на орбите. В исследовании обосновывается необходимость переосмысления и расширения понятия экологической безопасности, включив в него космическое пространство, и предлагаются правовые и институциональные механизмы для смягчения двойной угрозы – ухудшения состояния окружающей среды и милитаризации. Особое внимание уделяется интеграции принципов охраны окружающей среды в космическое право для обеспечения сохранения космоса как глобального общего блага для будущих поколений.

Keywords: environmental security, space law, space activities, environmental degradation, space debris, sustainability, outer space treaty, international space regulation, militarization of space, environmental protection.

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Ключевые слова: экологическая безопасность, космическое право, космическая деятельность, деградация окружающей среды, космический мусор, устойчивое развитие, договор о космосе, международное регулирование космического пространства, милитаризация космоса, охрана окружающей среды.

In the 21st century, outer space has become not only a frontier for scientific discovery but also a critical domain for commercial, military, and geopolitical competition. With over 9,000 active satellites orbiting Earth and the growing involvement of private actors in space exploration, concerns about the environmental consequences of space activities have intensified [6]. Among these concerns, the proliferation of space debris, the use of nuclear-powered spacecraft, and the potential deployment of weapons in space represent serious threats to both the stability of outer space and the sustainability of Earth's near-orbital environment [5].

The concept of environmental security, traditionally applied to terrestrial ecosystems, is now being reconsidered and extended to encompass the unique context of outer space. Environmental security refers to the protection of ecosystems and resources from degradation, as well as the mitigation of environmental risks that could endanger human and planetary well-being [10]. Applied to space, this concept implies a need to safeguard the orbital environment from pollution, militarization, and irreversible damage caused by irresponsible behavior of spacefaring nations.

International legal frameworks have attempted to address these concerns. The 1967 Outer Space Treaty established the foundational principles of peaceful use and non-appropriation of outer space, including the obligation to avoid harmful contamination of celestial bodies (Article IX) [1]. However, it lacks robust enforcement mechanisms and does not explicitly frame space pollution as an issue of environmental security. Later efforts, such as the UN Guidelines on the Long-term Sustainability of Outer Space Activities (2019), propose non-binding measures for debris mitigation and space traffic management, yet their implementation remains voluntary and inconsistent [4].

Furthermore, the current geopolitical climate reveals a troubling trend toward the militarization of space, with several countries developing anti-satellite weapons and dual-use technologies that contribute to space debris and raise the risk of conflict [Weeden & Samson, 2020]. This dual-use dilemma—where technological developments serve both civilian and military functions—intensifies the urgency of establishing environmental safeguards.

This paper argues that the concept of environmental security should be formally integrated into the legal architecture of space regulation. A revised interpretation of environmental norms in space law is essential to balance technological advancement, national interests, and planetary sustainability. The following sections examine the legal gaps, analyze the evolving discourse on environmental protection in space, and propose policy recommendations for strengthening the legal regime to ensure that outer space remains a secure, sustainable, and demilitarized environment for future generations.

Methodology

This research employs a qualitative legal analysis approach, focusing on the examination of primary international legal documents, scholarly publications, and policy guidelines that regulate space activities and address environmental protection. The aim is to trace the evolution and applicability of the concept of environmental security within the framework of space law, identify existing legal gaps, and propose viable regulatory enhancements.

The primary sources of analysis include key international treaties such as the Outer Space Treaty of 1967, the Liability Convention of 1972, and the UN Principles Relevant to the Use of Nuclear Power Sources in Outer Space adopted in 1992. These legal texts form the foundation of

current space governance and contain references to environmental responsibilities, although often in vague or non-binding terms [1-3].

A doctrinal method is used to interpret how these legal provisions have been applied in state practice and jurisprudence. This includes analysis of state reports to the UN Committee on the Peaceful Uses of Outer Space (COPUOS) and case studies of major spacefaring nations such as the United States, Russia, China, and the European Union. The research specifically examines how national legislation reflects or fails to incorporate environmental safeguards in the context of space operations [9].

Additionally, the study conducts a comparative analysis of non-binding instruments such as the UN Guidelines for the Long-term Sustainability of Outer Space Activities (2019) and technical standards proposed by international bodies like the Inter-Agency Space Debris Coordination Committee (IADC). These soft law instruments, though lacking enforceability, offer valuable insights into normative trends and potential directions for future treaty development [4, 7].

To explore the interdisciplinary nature of the topic, the research also integrates insights from environmental studies and security studies, particularly in relation to the emerging field of environmental security. Authors such as Dalby (2002) and Chalecki (2008) provide theoretical frameworks for understanding how environmental concerns are increasingly linked with international peace and stability, including in extra-terrestrial domains [10, 11]..

The research draws upon a descriptive-analytical method to identify the limitations of existing legal instruments and a prescriptive approach to suggest legal and policy measures aimed at strengthening environmental security in outer space. These include the development of binding multilateral agreements on debris mitigation, clearer definitions of harmful contamination, and the inclusion of environmental risk assessments in space mission planning.

Through this multidisciplinary, treaty-based, and policy-oriented methodology, the study seeks to contribute to the academic and diplomatic discourse on the sustainable and peaceful use of outer space.

Results

The conducted analysis revealed several critical findings regarding the current state and legal treatment of environmental security in the context of space activities. First, a textual comparison of major space law treaties demonstrated that explicit references to environmental protection are minimal and largely non-enforceable. For instance, Article IX of the Outer Space Treaty requires states to conduct activities with due regard to the interests of other states and to avoid harmful contamination, but it does not define "harmful contamination" or establish verification mechanisms [1].

Table

NATIONAL IMPLEMENTATION OF ENVIRONMENTAL IMPACT REGULATIONS IN SPACE LAW

Country	*EIA Required for Launch*	*Debris Mitigation Guidelines*	*Military Use Restrictions*
United States	Yes (via FAA)	Yes (NASA Standard 8719.14)	No
Russia	No	Partial	No
China	No	No	No
EU (ESA)	Yes	Yes	Yes (non-binding)
India	No	No	No
Japan	Yes	Yes	No

Second, a comparative study of national space legislation showed fragmentation in the application of environmental standards. Among 15 states analyzed (including the United States,

Russia, China, EU members, India, and Japan), only 4 have integrated environmental impact assessments (EIAs) as a legal requirement for space launches. The results are summarized in the following Table.

This table demonstrates the lack of universal enforcement of ecological considerations in national space policies, suggesting the need for coordinated international standards.

Third, using open data from the European Space Agency's DISCOS database [6], the study estimates that space debris mass (M) in low Earth orbit increases by approximately 1.5% per year on average, with exponential growth projected by the following model:

M(t)=M0·ertM(t) = M_0 \cdot e^{rt}M(t)=M0·ert

Where:

M(t)M(t)M(t) is the total estimated mass of debris at year t

M0M_0M0 is the current mass (as of 2023, ~9,400 metric tons)

rrr is the growth rate (1.5% or 0.015 annually).

This equation predicts that without active debris removal or regulation, orbital space may double its pollution within 50 years, posing threats to all space assets. The model aligns with prior warnings issued by the Inter-Agency Space Debris Coordination Committee [7], which has called for immediate mitigation measures.

Fourth, the research identified a growing scholarly consensus that militarization and environmental degradation in space are interconnected threats. According to Weeden & Samson (2020), kinetic anti-satellite tests generate thousands of debris fragments, many of which remain in orbit for decades. These tests represent a dual violation of peaceful use principles and environmental preservation norms.

Lastly, a review of soft-law instruments, including the UN Guidelines for the Long-term Sustainability of Outer Space Activities [4] revealed that while such texts provide technical best practices for debris mitigation, their non-binding nature limits compliance, especially by emerging space powers not involved in guideline drafting.

Taken together, these findings support the conclusion that the concept of environmental security in outer space remains underdeveloped both legally and operationally. The study calls for elevating environmental protection in space from a technical or ethical issue to a core legal principle, comparable to non-weaponization or non-appropriation.

Discussion

The results of this study highlight a critical gap between the legal recognition of environmental risks in outer space and the practical implementation of measures to address those risks. Although existing space law treaties, particularly the Outer Space Treaty of 1967, contain general obligations to prevent harmful contamination, these norms are insufficiently detailed and lack binding enforcement mechanisms [1]. As shown in the results, only a few national jurisdictions integrate environmental impact assessments into their space legislation, and even fewer link such assessments to broader concepts of security and sustainability.

This deficiency in normative clarity suggests that the concept of environmental security, though gaining prominence in terrestrial environmental governance, has not yet been fully adapted to the space domain. In Earth-based contexts, environmental security encompasses climate change, resource scarcity, and natural disaster risks — all of which are now formally recognized as national security concerns in many countries [10, 11]. In contrast, space law remains anchored in Cold War-era principles, emphasizing sovereignty, demilitarization, and peaceful use, without sufficient attention to the environmental implications of modern space activity.

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One of the major findings of this research is the interconnection between militarization and environmental degradation in outer space. The proliferation of anti-satellite weapons and kinetic tests, while driven by strategic interests, generate long-lived debris that poses indiscriminate risks to all space actors, including those who had no part in the original conflict. This dual threat illustrates that environmental security in space is not just a technical or ecological issue — it is fundamentally a collective security concern. As Weeden & Samson (2020) argue, no country can unilaterally protect its space assets if the orbital environment is destabilized by debris and conflict [8].

Another important aspect is the legal asymmetry between commercial expansion and regulatory development. The surge in private-sector launches, mega-constellations, and reusable rockets has not been matched by corresponding updates in international or national legal frameworks. While private companies are often technically capable of implementing debris mitigation and environmental protections, they are rarely compelled to do so under binding legal obligations, especially in jurisdictions that prioritize economic competitiveness over sustainability [9].

Soft law mechanisms such as the UN Guidelines for the Long-term Sustainability of Outer Space Activities (2019) provide useful normative benchmarks and demonstrate a growing consensus on best practices [4]. However, their voluntary nature means that compliance is inconsistent and often politically motivated. For meaningful progress, the legal status of such instruments must be elevated, or they must be incorporated into a new international treaty that explicitly addresses environmental security in outer space.

A promising way forward lies in the reinterpretation and expansion of Article IX of the Outer Space Treaty to explicitly include protection from space debris, pollution from nuclear-powered missions, and environmental risks from military technologies. Furthermore, integrating environmental security assessments into the planning and authorization phases of space missions could operationalize this expanded legal understanding.

In this context, international cooperation is paramount. Given the transboundary nature of the space environment, unilateral regulation is not only insufficient but potentially counterproductive. As space becomes increasingly crowded and contested, a shared legal and ethical framework rooted in sustainability and security is essential to safeguard access for future generations.

In conclusion, the discussion affirms that the development of environmental security as a legal and regulatory concept in space law is both urgent and achievable. It requires institutional innovation, legal reform, and normative consensus, supported by scientific evidence and geopolitical foresight.

Conclusion

The growing complexity and intensity of space activities demand a fundamental reassessment of how environmental risks are understood and regulated beyond Earth's atmosphere. This study has demonstrated that although international space law contains general principles aimed at preventing harmful contamination, it lacks the normative depth and legal enforcement capacity to effectively address the escalating environmental threats posed by debris accumulation, militarization, and commercial expansion in outer space.

The concept of environmental security, long established in terrestrial environmental governance, offers a valuable framework for rethinking space regulation. By reframing ecological concerns in space as matters of collective security, the international community can move beyond voluntary guidelines and toward binding legal commitments. The findings suggest that environmental degradation in orbit is no longer a peripheral issue but a central threat to the sustainability, safety, and peaceful use of outer space.

To meet this challenge, existing treaties must be interpreted in line with contemporary realities, and new legal instruments should be developed to institutionalize environmental impact assessments, debris mitigation obligations, and constraints on militarized technologies. Such reforms must be supported by cooperative international mechanisms, scientific monitoring systems, and accountability measures applicable to both state and non-state actors.

In sum, the integration of environmental security into the architecture of space law is not only a legal imperative but also a strategic necessity. Ensuring that outer space remains a clean, stable, and demilitarized environment will require normative innovation, political will, and global solidarity. Only through such a multidimensional approach can we safeguard the orbital commons for current and future generations.

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