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ENVIRONMENTAL PROTECTION IN OUTER SPACE: LEGAL CHALLENGES IN REGULATING SPACE DEBRIS AND EXTRATERRESTRIAL MINING ON THE MOON AND MARS

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Abstract

The rapid expansion of human activity in outer space has transformed what was once an aspirational frontier into a pressing legal and environmental concern. The rise of space debris in Earth's orbit and the looming reality of mining operations on the Moon and Mars present complex challenges for international law. While treaties such as the Outer Space Treaty of 1967 and the Moon Agreement of 1979 laid the foundation for peaceful and cooperative use of outer space, they remain inadequate in addressing the environmental and sustainability issues posed by modern technological developments.

This paper explores the legal gaps in the current framework, focusing on two critical areas: the management of space debris and the regulation of extraterrestrial mining. It highlights the shortcomings of existing liability mechanisms, the difficulty of enforcing responsibility for orbital pollution, and the tension between the non-appropriation principle and growing commercial interests in celestial resources. By analysing these challenges, the research underscores the urgent need for reform in space law to safeguard the extraterrestrial environment.

Drawing on comparative lessons from the Antarctic Treaty System, the United Nations Convention on the Law of the Sea, and global environmental principles, this study argues for a more comprehensive legal framework for outer space. Principles such as precaution, polluter-pays, and the common heritage of mankind are identified as essential tools to ensure responsible exploration and equitable access to resources. The paper further recommends the establishment of an international regulatory authority to oversee space resource activities and to promote sustainability and cooperation among states.

The conclusion emphasizes that the protection of outer space is not merely a legal necessity but a moral imperative. Preserving this shared domain requires a balance between scientific advancement, commercial exploitation, and environmental stewardship to ensure that the benefits of outer space exploration are enjoyed by present and future generations.

Keywords: Space Law, Space Debris, Lunar Mining, Martian Mining, Outer Space Treaty, Moon Agreement, Environmental Protection, Common Heritage of Mankind, International Cooperation, Sustainability.

1. Introduction

The twenty first century has witnessed a remarkable transformation in the scope and ambition of human activities beyond Earth. Once a domain reserved exclusively for state led exploration during the Cold War, outer

space has increasingly become a sphere of commercial, scientific, and even strategic interest. Countries such as the United States, China, and India are investing heavily in ambitious space missions, while private entities like SpaceX, Blue Origin, and other corporations have begun to treat space as the next frontier for technological innovation and profit. These developments, while commendable for their potential to advance human knowledge and capabilities, have also produced new legal and environmental challenges. Chief among these are the proliferation of space debris and the looming prospect of resource extraction from celestial bodies such as the Moon and Mars.

Environmental protection in outer space may sound like a futuristic concern, but it is already an urgent legal and policy issue[285]. Thousands of pieces of debris from defunct satellites to fragments generated by collisions currently orbit the Earth, posing risks to operational spacecraft, human missions, and even future exploration. Each launch adds to the risk, creating what scientists describe as a "Kessler syndrome[286]," where collisions generate more debris in a self-perpetuating cycle. Unlike terrestrial pollution, however, space debris cannot be managed through national environmental agencies or traditional clean-up operations. It requires collective governance, yet international law has remained largely static since the adoption of the Outer Space Treaty in 1967.

At the same time, serious discussions on the exploitation of extraterrestrial resources are underway. Lunar and Martian mining, once confined to science fiction, are now actively being considered by both state agencies and private corporations[287]. Proposals range from extracting lunar water ice for fuel production to exploiting Martian minerals for industrial purposes. While such ventures may accelerate technological progress and reduce the costs of long-term space habitation, they also present profound questions: Who owns these resources? How should they be extracted without causing irreversible environmental harm? And can developing countries ensure their participation in the benefits of such activities, or will space once again become an arena for inequitable distribution of wealth and power?

The legal framework governing outer space, though pioneering for its time, is no longer sufficient to meet these challenges. Adopted in 1967, the Outer Space Treaty stands as the foundation of international space law, recognizing outer space as the common domain of humanity while expressly forbidding any nation from claiming sovereignty over it. Yet it is silent on the specific issue of environmental protection beyond general principles of due regard and harm avoidance. The Moon Agreement of 1979 attempted to address resource exploitation more directly, but its limited ratification has left it without significant legal authority. Similarly, while the Liability Convention and the guidelines developed by the UN Committee on the Peaceful Uses of Outer Space (COPUOS) provide some mechanisms for addressing damage, they lack enforceability and comprehensive scope.

This research paper therefore seeks to critically analyse the legal challenges associated with environmental protection in outer space, focusing particularly on two pressing dimensions: the problem of space debris and the anticipated era of lunar and Martian mining. It will examine whether existing international law provides adequate mechanisms for regulating these issues or whether there is a pressing need for new frameworks. It will also explore how principles from international environmental law such as the precautionary principle, the polluter-pays principle, and the notion of sustainable development can be extended to the extraterrestrial domain.

[285] Lawcenta Team, Ensuring Environmental Protection in Outer Space: Legal Perspectives and Challenges, Law Centa (Oct. 15, 2024), https://lawcenta.com/environmental-protection-in-outer-space/
[286] Sentinel Mission, Kessler Syndrome – Definition & Detailed Explanation, SentinelMission.org (June 22, 2025), https://sentinelmission.org/space-exploration-glossary/kessler-syndrome/
[287] Pioneering Efforts to Mine Lunar and Martian Resources," MiningWorld (Jan. 23, 2025), https://miningworld.com/pioneering-efforts-to-mine-lunar-and-martian-resources/

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Furthermore, the paper will consider the geopolitical and ethical dimensions of these challenges. Should there be a global regulatory authority with competence to monitor and regulate resource exploitation beyond Earth? What role can and should developing nations play in ensuring that the benefits of extraterrestrial activities are equitably shared? Can lessons from other global commons, such as the high seas or Antarctica, inform the design of legal regimes for outer space? These questions are not merely speculative; they are central to ensuring that humanity's expansion into space does not replicate the mistakes of terrestrial exploitation, where unregulated activity has often led to environmental degradation and inequity.

In undertaking this inquiry, the objective of the paper is twofold: first, to map the inadequacies of the current legal framework in addressing the dual challenges of space debris and extraterrestrial mining; and second, to propose pathways for reform that emphasize sustainability, equity, and global cooperation. The aim is not only to highlight the urgency of addressing these issues but also to situate outer space within the broader discourse of environmental law and governance. By doing so, the research aspires to contribute to the ongoing debate on how humanity can responsibly balance exploration and exploitation with the imperative of environmental stewardship in outer space.

2. Current Legal Framework

When examining environmental protection in outer space, it is important to first understand the international legal framework that governs human activities beyond Earth. The current body of space law largely emerged during the Cold War, at a time when the primary concerns of states were sovereignty, security, and peaceful exploration. While these treaties created the foundation for space governance, they were not designed with modern environmental challenges such as space debris or resource extraction on celestial bodies in mind. A closer look at the Outer Space Treaty (1967), the Liability Convention (1972), the Moon Agreement (1979), and the COPUOS Guidelines reveals both their strengths and their significant limitations.

2.1. Outer Space Treaty, 1967

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (commonly known as the Outer Space Treaty, or OST) is considered the "constitution" of outer space law. Adopted in 1967[288], it establishes fundamental principles such as:

- Outer space is the "province of all mankind" and not subject to national appropriation.
- States bear international responsibility for national activities in space, whether carried out by governmental or non-governmental entities.
- States must avoid harmful contamination of outer space and celestial bodies.

While these provisions are important, the OST does not go far enough in addressing environmental protection. The reference to "harmful contamination" is vague and lacks specific standards. For example, there is no agreed definition of what constitutes contamination, nor any binding rules on how to prevent it. Moreover, the treaty places obligations on states but does not create an enforcement mechanism. As a result, while the OST establishes guiding principles, it is inadequate in dealing with modern problems such as orbital congestion, debris management, or commercial mining ventures.

[288] United Nations Office for Outer Space Affairs, *The Outer Space Treaty*, UNOOSA, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html

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2.2. Liability Convention, 1972

The Convention on International Liability for Damage Caused by Space Objects[289], adopted in 1972, is closely linked to the OST. It sets out the liability regime for damage caused by space objects. Under this framework:

- States are absolutely liable for damage caused on Earth or to aircraft in flight.
- In space, liability is fault-based meaning a state is only liable if negligence can be proven.

In theory, the Liability Convention could apply to environmental harm caused by space debris, such as a defunct satellite colliding with another satellite. However, the convention is focused narrowly on damage between states, not on broader environmental protection. For instance, if debris remains in orbit for centuries, creating risks for future missions, this long-term harm is not easily covered. Furthermore, the convention depends on diplomatic negotiations and claims processes, which are time-consuming and often avoided by states for political reasons. Thus, while the Liability Convention provides a legal avenue for compensation, it is ill-suited for preventive environmental measures.

2.3. Moon Agreement, 1979

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, adopted in 1979[290], was meant to expand on the OST by specifically addressing lunar and planetary activities. It introduced the concept of the "common heritage of mankind" and envisioned an international regime to govern the exploitation of natural resources on celestial bodies. Importantly, it stresses that activities should avoid harming the environment of the Moon and other celestial bodies.

However, the Moon Agreement has been ratified by only a handful of countries—none of the major spacefaring nations such as the United States, Russia, or China. This lack of acceptance severely limits its effectiveness. Additionally, the treaty speaks in broad aspirational terms without setting concrete environmental standards or enforcement mechanisms. As such, while it contains valuable principles, it has little practical impact on regulating lunar or Martian mining in today's context.

2.4. COPUOS Guidelines

The United Nations Committee on the Peaceful Uses of Outer Space (COPUOS)[291] has played a central role in developing "soft law" instruments such as guidelines for the long-term sustainability of outer space activities and debris mitigation. These guidelines recommend best practices, such as limiting the creation of new debris, de-orbiting defunct satellites, and sharing information among states.

The strength of the COPUOS guidelines lies in their flexibility and adaptability. However, their weakness is that they are non-binding. States are not legally obligated to follow them, and compliance depends entirely on goodwill and political commitment. In practice, this means that states or private companies may ignore these guidelines if they conflict with national interests or commercial priorities.

2.5. Legal Gaps

A critical analysis of these instruments reveals major legal gaps. None of the existing treaties directly confronts the scale of the space debris crisis or establishes binding obligations for its mitigation. Similarly, the legal regime for extraterrestrial mining remains underdeveloped, with no clear rules on sustainability, environmental safeguards, or

[289] United Nations Office for Outer Space Affairs, Liability Convention: Introduction, UNOOSA, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html

[290] UNOOSA, Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement), United Nations Office for Outer Space Affairs, https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/intromoon-agreement.html

[291] U.N. Office for Outer Space Affairs, Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space (rev. ed. 2010), https://www.unoosa.org/documents/pdf/spacelaw/sd/COPUOS-GuidelinesE.pdf

equitable benefit-sharing. Enforcement mechanisms are also weak or non-existent, leaving compliance largely voluntary.

In short, while the OST, Liability Convention, Moon Agreement, and COPUOS guidelines lay a foundation, they do not adequately regulate the environmental dimensions of space activities. The legal framework reflects the priorities of the 1960s and 1970s, not the challenges of the twenty-first century. To safeguard outer space as a sustainable environment, there is a pressing need for stronger and more specific legal instruments.

3. The Space Debris Problem

One of the most pressing challenges for environmental protection in outer space is the growing accumulation of space debris[292]. Broadly defined, space debris refers to any non-functional, human-made object in orbit, including defunct satellites, abandoned rocket stages, fragments from collisions, and even paint flakes or metallic particles resulting from past launches. Unlike on Earth, where waste can be disposed of or recycled, debris in outer space continues to orbit indefinitely and poses risks to ongoing and future missions. With thousands of satellites currently in orbit and the number increasing with commercial mega-constellations such as Starlink, the problem of debris has shifted from being a technical concern to a matter of international legal significance.

A central legal issue is liability for damage caused by space debris. Under the Outer Space Treaty, 1967 (OST) and the Liability Convention, 1972, states bear international responsibility for activities in outer space, whether carried out by governmental or non-governmental entities. Article VII of the OST establishes that states are internationally liable for damage caused by their space objects. The Liability Convention elaborates on this principle, holding launching states absolutely liable for damage caused on the surface of the Earth or to aircraft in flight, and liable on the basis of fault for damage caused elsewhere, including in outer space. However, applying these provisions to debris-related incidents is complex. Determining the "launching state" when multiple countries collaborate on a mission, or proving causation when debris fragments cannot be traced with certainty, creates significant gaps in enforcement. For instance, if a defunct satellite collides with an active one, identifying the responsible party is often legally and scientifically challenging.

Enforcement mechanisms also remain weak. There is no global enforcement body to monitor or penalize states or private actors who fail to mitigate debris creation. Instead, compliance is largely voluntary, guided by non-binding instruments such as the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) Guidelines on the Long-Term Sustainability of Outer Space Activities and the Inter-Agency Space Debris Coordination Committee (IADC)[293] Guidelines[294]. These provide technical recommendations, such as de-orbiting satellites after their operational life or minimizing debris during launch, but they lack legal force. Consequently, adherence depends on national implementation and goodwill rather than binding obligations, leaving room for non-compliance.

Some progress has been made through national space laws and policies. The United States, through agencies like NASA and the Federal Communications Commission (FCC)[295], imposes debris mitigation requirements on commercial operators, particularly for satellite constellations. The European Union, under the

[292] New Space Economy, International Efforts in Space Debris Mitigation, New Space Economy (Oct. 1, 2024), https://newspaceeconomy.ca/2024/10/01/international-efforts-in-space-debris-mitigation/

[293] Inter-Agency Space Debris Coordination Committee, IADC-02-01, IADC Space Debris Mitigation Guidelines (Revision 2, Mar. 2020), https://orbitaldebris.jsc.nasa.gov/library/iadc-space-debris-guidelines-revision-2.pdf

[294] Sophie Goguichvili et al., The Global Legal Landscape of Space: Who Writes the Rules on the Final Frontier?, WILSON CTR. (Oct. 1, 2021), https://www.wilsoncenter.org/article/global-legal-landscape-space-who-writes-rules-final-frontier

[295] Federal Communications Commission, Space (visited Sept. 21, 2025), https://www.fcc.gov/space

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European Space Agency (ESA), follows strict debris mitigation standards and promotes sustainability in space operations. India, while still developing its commercial space sector, has begun incorporating debris mitigation into its national space policy through the Indian Space Research Organisation (ISRO) and the recently established Indian National Space Promotion and Authorisation Centre (IN-SPACE)[296]. However, despite these national efforts, a lack of harmonization means that differing standards could create loopholes for operators seeking more lenient jurisdictions.

Thus, the space debris problem highlights the intersection of environmental sustainability and international law. While existing treaties recognize state liability, they were drafted at a time when debris was not foreseen as a major hazard. Today, the challenge lies in updating international frameworks, strengthening enforcement, and ensuring that national laws collectively address a problem that is global in scope. Without legal innovation, the continued growth of debris could make some orbits unusable, threatening the very future of space exploration and exploitation.

3.1. Lunar and Martian Mining

The increasing attention toward lunar and Martian mining has become one of the most debated issues in contemporary space law[297]. With rapid advances in space technology and the growing ambitions of both state and private actors, the idea of extracting resources from celestial bodies has moved from the realm of science fiction to a near-future reality. However, this development raises several pressing legal and ethical concerns. The core issues involve sovereignty over celestial bodies, the regulation of commercial exploitation, sustainability of extraterrestrial resource extraction, and the equitable distribution of benefits, especially for developing nations.

3.2 Sovereignty and the Non-Appropriation Principle

At the heart of the legal debate lies the non-appropriation principle, enshrined in Article II of the Outer Space Treaty (1967), which prohibits national appropriation of the Moon or other celestial bodies "by claim of sovereignty, by means of use or occupation, or by any other means." This provision was intended to ensure that outer space remained a global common, free from territorial claims and open to all states.

However, the non-appropriation principle presents challenges when applied to resource extraction. While states cannot claim sovereignty over the Moon or Mars, it remains ambiguous whether this also prohibits ownership of extracted resources. Some states, such as the United States through its Commercial Space Launch Competitiveness Act (2015)[298], and Luxembourg through its Space Resources Law (2017)[299], have interpreted the Treaty as allowing private ownership of extracted resources without implying sovereignty over the celestial body itself. Critics argue that such unilateral interpretations erode the spirit of international cooperation and risk a "space race" for resource control. The absence of a universally accepted framework creates legal uncertainty, particularly in balancing exploration with the prohibition of appropriation.

3.3. Commercial Exploitation and the Role of Private Actors

The involvement of private corporations, including SpaceX, Blue Origin, and other emerging space enterprises, has accelerated the debate over extraterrestrial mining. Unlike the Cold War era, where space activities were

[296] Indian National Space Promotion and Authorization Center, IN-SPACe, https://www.inspace.gov.in/inspace
[297] Gerald B. Sanders, Julie E. Kleinhenz & Dale Boucher, Lunar Mining and Processing: Considerations for Responsible Space Mining & Connections to Terrestrial Mining, NASA Technical Reports Server (2023), https://ntrs.nasa.gov/api/citations/20230012983/downloads/Lunar%20Mining-Responsible%20ISRU_Draft2.pdf
[298] Pub. L. No. 114-90, § 109, 129 Stat. 704, 712 (2015), https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf
[299] Law Library of Congress, Luxembourg Law on Use of Resources in Space Adopted, GLOBAL LEGAL MONITOR (Aug. 22, 2017), https://www.loc.gov/item/global-legal-monitor/2017-08-22/luxembourg-law-on-use-of-resources-in-space-adopted/

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dominated by state actors, the contemporary space environment is increasingly shaped by private investment and commercial interests[300]. Companies are investing in technologies for lunar bases, asteroid mining, and eventual colonization projects.

Yet, private participation raises questions about accountability and regulation. International treaties like the Outer Space Treaty impose responsibility on states for national activities in outer space, whether conducted by governmental or non-governmental entities (Article VI). However, as corporations expand their presence, states must balance the encouragement of innovation with the need for oversight. Without clear international regulation, private actors may prioritize profit over environmental protection and equitable use, potentially leading to exploitation reminiscent of historical colonial practices on Earth.

3.4. Sustainability and Environmental Concerns

Mining activities on the Moon and Mars also present significant environmental challenges. Celestial bodies, though lacking ecosystems like Earth, are not devoid of environmental value. The lunar surface contains fragile regolith[301] and unique geological features, while Mars harbors resources such as water ice that could support future human settlement. Large-scale extraction could permanently alter these environments, cause contamination, and compromise scientific research.

International environmental law principles provide useful guidance. The precautionary principle suggests that in the face of scientific uncertainty, activities that may cause irreversible harm should be restricted. Similarly, the polluter-pays principle could be adapted to ensure that those responsible for environmental damage in space bear the costs of mitigation. Unfortunately, current space law lacks binding environmental standards for resource extraction. While COPUOS has issued soft law guidelines on sustainability, they are non-binding and insufficient to address large-scale mining operations. The absence of enforceable rules heightens the risk that resource extraction will proceed without adequate safeguards.

3.5. Equity and the Interests of Developing Nations

A further challenge lies in ensuring that the benefits of lunar and Martian mining are shared equitably. The Moon Agreement (1979), though ratified by only a handful of states, explicitly refers to the Moon and its resources as the "common heritage of mankind" and envisions an international regime to govern resource exploitation. However, major spacefaring nations such as the United States, Russia, and China have not ratified the Agreement, limiting its effectiveness.

Developing countries fear marginalization in this emerging sector. Without meaningful participation, they risk exclusion from the economic and technological benefits of extraterrestrial mining. This concern parallels debates under the United Nations Convention on the Law of the Sea (UNCLOS) regarding deep-sea mining, where mechanisms like the International Seabed Authority aim to ensure shared benefits. A similar institutional framework for outer space could help balance the interests of spacefaring powers with those of developing states.

Lunar and Martian mining encapsulates the broader tensions within space law: the drive for exploration and economic gain versus the commitment to cooperation, sustainability, and equity. Sovereignty disputes under the non-appropriation principle, the unregulated rise of private actors, environmental risks, and the marginalization of developing nations all underscore the inadequacy of current legal frameworks. Unless a comprehensive, cooperative regime emerges, resource

[300] India Brand Equity Foundation, India's Private Spacetech Boom: A New Era Unfolds, IBEF (Sep. 5, 2025), https://ibef.org/blogs/india-s-private-spacetech-boom-a-new-era-unfolds
[301] NASA, What Is Lunar Regolith?, NASA SCIENCE (Apr. 29, 2025), https://science.nasa.gov/biological-physical/what-is-lunar-regolith/

extraction beyond Earth may replicate the unsustainable and inequitable practices of terrestrial history, rather than charting a new path of shared benefit for all humanity.

4. Comparative Angle

The challenges of environmental protection in outer space are not entirely unprecedented. International law has already dealt with environments that are beyond the jurisdiction of any single state, such as the high seas, Antarctica, and even the atmosphere. By examining how international regimes like the Antarctic Treaty System (ATS)[302], the United Nations Convention on the Law of the Sea (UNCLOS), and global environmental principles operate, important lessons can be drawn for regulating space activities.

The Antarctic Treaty System, established in 1959, is often regarded as a model for cooperative governance of a global common. It designates Antarctica as a scientific preserve, prohibits military activity, and restricts commercial exploitation. Later instruments, such as the Protocol on Environmental Protection to the Antarctic Treaty (1991), reinforced the principle that Antarctica should be protected for peaceful and environmental purposes. This treaty system demonstrates how states can agree to prioritize science, conservation, and sustainability over short-term economic interests. A similar approach could be adopted for the Moon and Mars, ensuring that these celestial bodies are preserved for scientific inquiry and not subjected to reckless extraction.

The Law of the Sea (UNCLOS, 1982)[303] provides another useful analogy. UNCLOS recognizes the high seas and deep seabed as the "common heritage of mankind," a concept that resonates with the non-appropriation principle in the Outer Space Treaty. The International Seabed Authority (ISA) was established to regulate deep-sea mining, distribute benefits equitably, and protect the marine environment. This institutional model could inspire the creation of a global regulatory body for outer space that balances the interests of developed and developing nations while ensuring environmental sustainability.

From global environmental law, several principles stand out. The precautionary principle suggests that where there are threats of serious or irreversible harm, lack of full scientific certainty should not be a reason to postpone preventive measures. Applied to outer space, this principle would mean regulating mining and debris management even before the full risks are known. The polluter-pays principle could impose liability on states or corporations that generate space debris or cause damage to extraterrestrial environments, thus creating incentives for responsible conduct. Lastly, the principle of common heritage of mankind, which underpins both UNCLOS and the Moon Agreement, emphasizes that no single nation should monopolize resources and that benefits should be shared with all humanity. Although underused in space law, this principle remains vital for equity and fairness, particularly to safeguard the interests of developing countries.

Taken together, these comparative regimes demonstrate that international law already has models for balancing sovereignty, commerce, and environmental stewardship in areas beyond national jurisdiction. What is required is a political willingness to extend these lessons to outer space before irreparable harm occurs.

5. Recommendations

While existing treaties like the Outer Space Treaty and the Moon Agreement laid down important foundations, they are insufficient to meet the modern challenges of space debris and extraterrestrial mining. As space activities intensify, the legal framework must evolve. The following recommendations aim to strengthen environmental protection in outer space.

[302] Standing Committee on Antarctic Research, Antarctic Treaty System, SCAR, https://scar.org/policy/antarctic-treaty-system
[303] Admiralty Law Guide, United Nations Convention on the Law of the Sea (UNCLOS), http://www.admiraltylawguide.com/conven/unclostable.html

5.1. Call for a New Treaty or Amendments:

There is an urgent need to revisit the Outer Space Treaty of 1967. Although it prohibits national appropriation and promotes peaceful use, it is silent on concrete environmental obligations. A new treaty—or at least a comprehensive amendment protocol should explicitly address sustainability, space debris mitigation, and environmental impact assessments for lunar and Martian projects. This would align outer space governance with contemporary environmental law standards.

5.2. Establish a Global Regulatory Authority:

Drawing from the International Seabed Authority under UNCLOS, a dedicated International Space Resources Authority could be created under the United Nations framework. Such a body would regulate the extraction of extraterrestrial resources, monitor compliance with environmental standards, and ensure equitable benefit-sharing among states. Importantly, it would give developing nations a seat at the table, reducing the risk of monopolization by a handful of spacefaring countries.

5.3. Incorporate Sustainability Practices:

Environmental protection in space requires preventive and adaptive strategies. States and private actors should adopt debris mitigation technologies, recycling practices for spacecraft, and sustainable mining methods that minimize ecological disturbance on the Moon or Mars. Just as environmental impact assessments are mandatory for large projects on Earth, they should also become a requirement for space missions, particularly those involving mining.

5.4. Promote International Cooperation and Capacity-Building:

Outer space is a shared domain, and its governance cannot be left to individual states or corporations. Enhanced cooperation through the UN Committee on the Peaceful Uses of Outer Space (COPUOS) and other multilateral platforms is essential. Moreover, capacity-building programs should be introduced to support developing countries in participating in space exploration. This would not only uphold equity but also create a broader consensus for sustainable governance.

5.5. Integrate Environmental Principles into Space Law:

The principles of precaution, polluter-pays, and common heritage should be expressly incorporated into future space law instruments. This would bring coherence between terrestrial environmental law and extraterrestrial governance, ensuring that space activities are conducted responsibly.

In sum, the protection of the space environment requires proactive reforms. Without strong governance, space debris and mining activities could repeat the mistakes of Earth overexploitation, inequality, and environmental degradation. By learning from existing international regimes and adopting a forward-looking treaty framework, the international community can ensure that space remains a domain for peaceful exploration and shared human progress.

6. Conclusion

The exploration of outer space has entered a decisive phase where the dreams of humanity are rapidly colliding with the realities of law and sustainability. What was once a distant ambition has now become a matter of pressing urgency: the accumulation of space debris in Earth's orbit and the prospect of mining the Moon and Mars are no longer hypothetical but immediate challenges. This paper has examined the gaps in the current legal framework, most notably the limitations of the Outer Space Treaty and the Moon Agreement, and has shown that they are inadequate to address modern environmental concerns.

Space debris presents a unique problem of responsibility and liability. While treaties like the Liability Convention attempt to regulate damage caused by space objects, they fall short when dealing with the cumulative and

diffuse nature of debris pollution. Similarly, the future of extraterrestrial mining raises profound questions about sovereignty, equity, and environmental stewardship. The non-appropriation principle prohibits states from claiming territory in space, yet there is growing pressure from private companies and spacefaring nations to exploit lunar and Martian resources. Without clear rules, such activities risk not only geopolitical conflict but also irreversible damage to extraterrestrial environments.

Comparative international regimes such as the Antarctic Treaty System and UNCLOS demonstrate that it is possible to balance exploration with conservation. Their emphasis on scientific cooperation, the common heritage of mankind, and environmental safeguards provide valuable lessons for space law. Incorporating principles like precaution, polluter-pays, and sustainability into the governance of outer space is not just desirable but necessary.

The way forward must be rooted in cooperation and foresight. A new or amended treaty framework, possibly overseen by a global regulatory body, could ensure that the benefits of space are shared equitably while minimizing ecological risks. Developing nations must also be included in this governance structure to uphold fairness and legitimacy.

Ultimately, the challenge is to ensure that humanity's expansion into space does not repeat the mistakes made on Earth. The protection of outer space is not only a legal or scientific obligation but a moral one, as it involves safeguarding a domain that belongs to all of humankind and to future generations.