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Space Environmental Protection Governance: A Decentralized Model

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Abstract

The existing space governance model characterized by ambiguous and outdated laws requires improvement. Scholars and experts suggest that institutional innovation and a decentralized governance model hold the potential for addressing challenges in governing space environmental protection. This paper aims to propose feasible and efficient methods for managing concerns related to the environment in outer space while advocating a polycentric approach towards addressing issues arising from factors such as human-generated space debris. Furthermore, it emphasizes that multiple entities including state governments, international organizations, and non-state actors should take measures to strengthen bottom-up approaches toward effectively protecting the environment in outer space. Within a decentralized model of space governance, sustainable development and exploitation of the space environment become achievable goals. Thus, human interests can be comprehensively considered and safeguarded in an era characterized by the commercialization of outer space.

Keywords: Environmental protection; legal issues; a decentralized model; sustainable development.

The benefits of outer space in fields such as telecommunications and remote sensing have been extensively discussed and revealed by humans.[1] However, the issue of pollution accompanying these activities is increasingly prominent. Simultaneously, the current technological state of addressing these issues poses challenges to safeguarding the environment of outer space. This paper aims to explore the causes and current situation that have led to these circumstances, emphasizing the failure of commercial actors to fulfill self-

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1 Diederiks-Verschoor, I. H. Ph, Environmental Protection in Outer Space, German Yearbook of International Law, Vol. 30, pp. 144.

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monitoring obligations, uncertainties surrounding damage consequences, and inadequacies within the legal framework for governing outer space. The urgency of protecting the environment in outer space necessitates considering new governance models.

1. Introduction

The comprehension of the current status and underlying factors is crucial in advancing the protection of the outer space environment, considering its significance in the ongoing development on environmental preservation. In this section, we will address three key aspects: (1) the technological advancements and challenges associated with outer space environmental protection; (2) the causal factors contributing to this existing situation; and (3) the indispensability of preserving the environment in outer space.

1.1. Technical status quo and Dilemma of Outer Space Environmental Protection

Nearly 70 years have passed since mankind successfully launched the inaugural artificial satellite into outer space, a significant milestone that spurred numerous countries to embark on similar endeavors. This groundbreaking event not only paved the way for innovative approaches in conducting experiments with far-reaching implications for humanity's future but also introduced an unprecedented dimension to our recent history.[2] From a legal perspective, the existing international legal framework for outer space primarily encompasses a series of robust regulations, including the Outer Space Treaty, Liability Convention, and United Nations Committee on the Peaceful Uses of Outer Space (COPUOS). These treaties predominantly govern activities in outer space. However, while addressing certain aspects related to environmental protection in outer space, the current legal framework does not comprehensively address specific challenges posed by space debris, pollution, and the long-term sustainability of space activities. This insufficiency is gradually being recognized as a potential threat to human society.[3]

In terms of technology, the timely mitigation of potential damage caused by space debris is of paramount importance. Space agencies and organizations worldwide have developed state-of-the-art tracking systems and cutting-edge technologies to effectively monitor space debris and accurately predict potential collisions with operational satellites and spacecraft.[4] Furthermore,

2 Diederiks-Verschoor, I. H. Ph, Environmental Protection in Outer Space, German Yearbook of International Law, Vol. 30, pp. 144.

3 Report of the United Nations Committee on the Peaceful Uses of Outer Space, UN Doc. A/5549, 24 September 1963, para. 18, 8.

4 J. Markkanen, Real-time space debris monitoring with EISCAT, Volume 35, Issue 7, 2005, Pages 1197-1209.

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innovative solutions such as ground-based lasers and nets for capturing and deorbiting space debris have been proposed. As previously discussed, while the allure of space has captivated the human imagination for decades, technological advancements in space exploration and development have inadvertently given rise to environmental challenges. These challenges possess the capacity to envelop humanity in a closed loop, underscoring the imperative need for a robust legal framework aimed at safeguarding the integrity of the space environment.

1.2. Four causes of the current situation

1.2.1. Non-fulfilment of self-Monitoring Obligations by Commercial Actors in Outer Space

One crucial aspect leading to this predicament is the inability of commercial actors operating in outer space to effectively meet their self-monitoring responsibilities. The rapid expansion of the commercial space industry has led to a surge in space debris and associated environmental risks. Despite notable technological progress, ensuring adequate monitoring and regulation of activities carried out by these entities continues to pose significant challenges. While space technology has been at the forefront of technological advancements, intellectual property protection concerning outer space activities has recently gained wider attention. This can be attributed, in part, to the shift from government-owned initiatives to private and commercial ventures. Moreover, although the existing legal framework of outer space law mandates that space actors assume responsibility for their actions and engage in self-monitoring, it lacks corresponding penalties. Consequently, perceived weaknesses and incompleteness within this legal framework may lead commercial actors operating in outer space to not diligently fulfill their obligations, thereby posing a threat to the integrity of the extraterrestrial environment.

1.2.2. Uncertainty Regarding the Timing and Location of Damage Consequences

The uncertainty surrounding the temporal and spatial consequences of damage complicates the matter at hand, posing challenges for formulating effective measures to safeguard the outer space environment. Given the vast expanse of space, immediate manifestation or confinement of damage effects to a specific location may not be guaranteed. For instance, shortly after the launch of Sputnik in 1957, Earth's orbit started accumulating space debris; however, it is worth noting that such debris might have existed even before this event, potentially originating from historical jet propulsion incidents dating back as far as Pascal B's experiment.[5]

5 Harrington, Rebecca (5 February 2016). "The fastest object ever launched was a manhole cover – here's the story from the guy who shot it into space", <www.businessinsider.com>, accessed 10 September 2023.

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1.2.3. Uncertainty Regarding the Causal Relationship between the Injurious Act and the Resulting Consequences of the Injury Persists

Moreover, establishing a causal relationship between detrimental actions and their outcomes often involves inherent uncertainty. The complexity associated with linking space operations to ecological effects presents challenges in attributing liability and implementing regulatory measures. Legally speaking, there are three categories of causative associations: proximate cause, proximate cause relationship, and remote cause. These connections require meticulous evaluations while introducing uncertainties regarding legal culpability. Consequently, the intricate nature of assessing legal causation alongside assigning responsibilities makes it difficult to establish correlations between harmful actions and subsequent environmental repercussions.

1.2.4. Incompleteness of the Legal Regime of Outer Space

Despite the substantial incorporation of robust legal statutes and conventions within the legal framework governing outer space, there persists a notable deficiency in terms of enforceability and international recognition. This inadequacy is primarily manifested through two key aspects: (1) the absence of explicit regulations of environmental protection, and (2) the lack of clear constraints on actors' conduct.

1.2.4.1. Lack of Clear Regulation of Environmental Protection Aspects

The inadequacy of the existing legal framework governing outer space poses a significant concern. Despite the presence of international agreements like the Outer Space Treaty and COPUOS, there is a notable absence of comprehensive regulations addressing environmental protection. While these treaties primarily concentrate on preventing military activities in space and encouraging peaceful utilization, their limited attention to safeguarding the environment gives rise to apprehensions. Overlooking environmental issues in outer space may ultimately endanger peace if substantial deterioration occurs, thereby giving rise to multiple threats as delineated by both Article 34 and Article 39 of the United Nations Charter.

1.2.4.2. Failure to Limit the Subject of the Act

Furthermore, the Outer Space Treaty and its associated agreements lack explicit provisions regarding the entities authorized to cause harm to the outer space environment, leading to varying interpretations and allowing unchecked detrimental activities to persist. For instance, while the Liability Convention defines a launching state as "a state that launches or procures the launch of a space object and a state from whose territory or facility a space object is launched,"[6] it can be argued that with the significant shift in roles

6 Liability Convention, Art. 1.

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from governmental bodies to private entities in space utilization and exploration, the existing legal framework may be considered limited when it comes to assigning legal responsibilities to private actors.[7]

1.3. The Necessity of Protecting the Environment of Outer Space

Gradually, research findings have increasingly recognized the importance of proactively preventing potential detrimental interference with the peaceful utilization of outer space and the imperative to safeguard the integrity of the outer space environment.[8]

1.3.1. Types and Sources of Outer Space Hazards

First and foremost, the imperative of safeguarding the outer space environment is indisputable. There are various categories and origins of threats to the celestial milieu, including space debris, orbital hazards, space weather anomalies, and space junk, with particular emphasis on space debris as the most significant. Space debris encompasses remnants from meteoroids and asteroids that either orbit independently or collide with spacecraft resulting in damage, as well as numerous anthropogenic scenarios. It constitutes a substantial peril in outer space comprising defunct satellites, discarded rocket stages, fragments from previous collisions, and even minuscule particles such as paint chips. These objects can traverse at high velocities thereby posing a collision risk to operational spacecraft. A 2011 report by the National Research Council cautioned NASA about the critical level of orbital space debris. According to certain computer models, there has been an attainment of a crucial threshold for the quantity of space debris whereby it perpetuates collisions leading to further generation of debris thus augmenting spacecraft failure risks. The report advocates for international regulations aimed at limiting debris accumulation while also calling for research into disposal methods.[9]

1.3.2. Significant Consequences of Damage to the Environment of Outer Space

In addition to posing direct threats to operational satellites and spacecraft, the enduring ramifications resulting from such damages can significantly impact future space exploration efforts and our capacity to exploit extraterrestrial resources effectively. The obliteration of celestial bodies like the Moon or Mars has potential implications for impeding scientific research initiatives and hindering human colonization endeavors. Environmental degradation possesses the capability to undermine sustainable human

7 Mathew Smith, Commercialized Space and You, HARV. UNIV. (June 11, 2018), <https://perma.cc/4KYW-4BUS>, accessed 10 September 2023.

8 Report of the United Nations Committee on the Peaceful Uses of Outer Space, UN Doc. A/5549, 24 September 1963, para. 18, 8.

9 Space junk at tipping point, says report Archived 21 December 2017 at the Wayback Machine, BBC News, 2 September 2011.

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development while exacerbating adverse effects on commercial economies, thereby perpetuating an unfavorable cycle. Moreover, as astutely pointed out by Jenkins, alterations in environmental conditions hold the potential for instigating circumstances that fall within Article 34 of the United Nations Charter while possibly constituting a menace to global peace as outlined in Article 39.[10]

2. Status and Causes

Following the previously provided background, an urgent resolution is imperative for addressing the current challenges in the field of outer space environmental protection. The uncertainty surrounding causation between destructive actions and their consequences, the allocation of responsibility, the balance between common interests and private interests, as well as the overall governance model all exert a significant impact.

2.1. Does the Uncertain Causal Relationship between the Damaging Act and the Result Introduce Bias in Liability Assumption?

The presence of such uncertain causation further complicates the determination of legal liability, which is already a challenging task and may give rise to biases and errors in delineating legal responsibilities. This issue will be further elaborated upon in the subsequent two points.

2.1.1. Ambiguity of Causation within the Domain of Outer Space Law

Firstly, under international conventions, the launching state bears absolute liability for any damage caused by its space object to the Earth's surface or aircraft in flight.[11] Essentially, irrespective of fault, the launching state is obligated to provide compensation for harm inflicted upon individuals or property on Earth or within aircraft. However, concerning damages suffered by a space object or individuals aboard it while in outer space, the launching authority may argue that liability for compensation only arises if such damage can be attributed to their fault or that of persons under their responsibility.[12] Consequently, this introduces uncertainty into the existing legal framework governing outer space law and conflicts with the causation assessment system discussed earlier.

2.1.2. Difficulties Arise in Establishing Liability Due to the Uncertainty Surrounding the Statute of Limitations between the Injurious Act and Its Resultant Consequences

Another aspect of the uncertainty surrounding causation lies in the challenge of determining the statute of limitations for harmful actions and their

10 C. W. Jenks, Space Law, New York 1965, 280-282.
11 Liability Convention, Art. 2.
12 Liability Convention, Art. 2-3.

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consequences. Given that space activities often span prolonged periods, it may take time for the effects of these actions to become apparent. This temporal ambiguity poses a significant obstacle to accurately assigning responsibility. In 1981, NASA initiated a study aimed at enhancing our understanding of orbital debris within the critical mass region, estimating approximately 5,000 objects at that time. Subsequently, new objects were continually discovered through ground-based Electro-Optical Deep Space Surveillance (GEODSS) systems in subsequent years. By 2005, this number had been revised to 13,000 objects;[13] further research conducted in 2006 increased the count to 19,000 objects due to anti-satellite tests and satellite collisions. Finally, in 2011, NASA revealed an alarming figure of 22,000 objects.[14]

Taking a comprehensive view, the proliferation of space debris does not demonstrate a direct correlation with satellite launches based on existing data. Notably, there was an abrupt increase in its volume within only one year from 2005 to 2006. The factors contributing to this occurrence cannot be exclusively ascribed to the satellites deployed during that particular period alone. Even when considering satellite launches spanning multiple decades, determining responsibility remains challenging.

2.1.3. Liability of Actors for Consequential Damage Arising from the Five Treaties

The responsibility framework in outer space law, particularly concerning the responsibility associated with the five major treaties, faces challenges when addressing indirect damage. These treaties, such as the Outer Space Treaty and the Liability Convention, were formulated during a period dominated by state-led space activities. However, with the emergence of commercial actors and increasing complexity in contemporary space endeavors, lines of accountability have become blurred. The uncertainty surrounding whether commercial actors should assume liability for damages arising from their activities adds intricacy to the legal landscape.

2.2. Reconciling and Striking a Balance between the Collective Welfare and Individual Interests of All Humanity

In recent years, with an increasing involvement of private entities in commercial activities within outer space, numerous countries have

13 In the time between the writing of Klinkrad (2006) Chapter 1 (earlier) and the Prolog (later) of Space Debris, Klinkrad changed the number from 8,500 to 13,000-compare pp. 6 and ix.

14 "Space Junk Threat Will Grow for Astronauts and Satellites" Archived 9 April 2011 at the Wayback Machine, Fox News, 6 April 2011, <http://www.foxnews.com/scitech/2011/04/06/space-junk-threat-grow-astronauts-satellites/>, accessed 10 September 2023.

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implemented corresponding regulations. The Commercial Space Launch Act has effectively facilitated access to launch licenses and government-developed space technology for these commercial entities. Both legislatively intended and practically impactful, this act has significantly broadened private sector utilization of outer space. To further stimulate such endeavors within this domain, Congress enacted the Space Act which provides enterprises with enhanced certainty while undeniably propelling advancements in privately driven commerce. However, the existing legal framework of outer space law fails to adequately ensure comprehensive protection for outer space as a common heritage of humankind, particularly in terms of environmental preservation amidst escalating human commercial activities and conflicts arising from shared resources between humanity's collective interests and current economic pursuits.

2.3. Ambiguity and Stagnation in the Governance Model of Outer Space Environmental Protection

The lack of clarity regarding the legal framework and institutional arrangements in outer space poses a significant obstacle in addressing the challenge posed by space debris. Consequently, an essential unresolved question emerges: what is the optimal structure for assigning responsibility for regulating and executing space debris cleanup efforts? More precisely, should this responsibility lie with launching states, participating states, and commercial space companies or necessitate a collaborative global endeavor? Furthermore, determining how costs related to cleanup operations as well as restoration and maintenance activities are allocated continues to be a subject of debate.

Simultaneously, with increasing growth in commercial space endeavors like satellite deployment and resource development, there is a growing intensity in disputes concerning sustainability issues and efforts to mitigate negative impacts on the outer space environment. The international community holds diverse perspectives on formulating suitable policies and legal frameworks in this context. Nevertheless, it is important to acknowledge that there are several deficiencies within the current international legal framework; most notably being its lack of explicit provisions for environmental protection. Additionally, governance models must adapt accordingly to accommodate evolving space activities. Therefore, it becomes imperative to undertake reforms within our legal system as adherence to outdated traditional governance models will only worsen the deteriorating condition of our outer space environment.

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3. Current Status and Key Controversial Topics in Research

Humanity is progressively evolving into a spacefaring civilization, with space poised to play a pivotal role in future human development.[15] Undoubtedly, the significance of space is growing exponentially, necessitating the establishment of a more robust legal framework for outer space patents to facilitate humanity's exploration and utilization of this final frontier.[16]

3.1. Revealing the Vulnerabilities of Traditional Models through Decentralized Governance Models

Conventional space governance models have heavily relied on national actors and top-down regulatory frameworks, which are demonstrating signs of inadequacy in the face of contemporary challenges. To effectively address these issues, the outdated model's vulnerability is being dismantled, paving the way for decentralized governance models to gradually gain prominence.

3.1.1. Establishment of a Semi-Independent Idealized Space Governance Ring System as a Basis

The Artemis Accords serve as a foundational framework for a semi-autonomous space governance model. Spearheaded primarily by the United States, these accords signify a political commitment aimed at establishing an international structure to govern civil space exploration activities and the utilization of outer space by national space agencies. This comprehensive framework encompasses provisions for safeguarding the distinctive attributes of outer space and mitigating collisions during space operations. Adopted in October 2020, the Artemis Accords consist of 13 articles that provide a principled basis for sustainable lunar exploration and exploitation of celestial bodies, including their natural resources. While partially rooted in the Outer Space Treaty, this initiative introduces significant innovations in international space law by replacing anticipated regulatory approaches with phased principles of adaptive governance.[17]

This study aims to establish an idealized society in outer space that aligns with the existing legal framework by employing predetermined scenarios related to the provision of space resources and the mitigation of space debris. For instance, as per Article 11, Paragraph 5 of the Artemis Accords, signatory parties are obliged to provide "essential information regarding their activities' location and nature" while establishing a precautionary "safety zone" against potential detrimental interference. This safety zone bears resemblance to the

15 S. Rep. No. 101-266, para. 5.

16 Dan L. Burk, Application of United States Patent Law to Commercial Activity in Outer Space, 6 Santa Clara Comput. & High-Tech. L.J. pp. 295, 329. (1991).

17 Rossana Deplano, The Artemis Accords: Evolution or revolution in international space law?, International & Comparative Law Quarterly, Volume 70, Issue 3, July 2021, pp. 799-819.

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aforementioned semi-idealized system.[18] As Danilenko aptly stated: "While anticipatory regulation may contribute to establishing a broad legal framework for future state activities, it becomes precarious when attempting to regulate complex technical or economic issues.[19]

3.1.2. Supplementary Application of Polycentric Spatial Governance System

In the current global context, situated at the intersection of multilateralism and unilateral national legislation, it is imperative to incorporate the trend towards globalization into the development of a legal framework for outer space. This would position the Artemis Accords as a catalyst for a more universally applicable multi-central governance model in outer space legislation. The Accords require signatory countries to proactively undertake measures, and future multilateral negotiations will focus on regulating these actions. While this approach may deviate from the traditional method of regulating outer space activities outlined by the UN Outer Space Treaty, it holds immense potential to enhance regulatory effectiveness and transcend an outdated governance paradigm in outer space.

3.2. Bottom-up Approach to Space Environmental Protection by Various International Subjects

Traditionally, the responsibility for safeguarding the outer space environment has primarily rested with national actors based on the "launching state" principle, as mentioned earlier. However, given the increasing involvement of non-governmental entities such as private space companies and international organizations, there is a need to reform the existing legal framework. It is imperative to adopt a more targeted approach that ensures case-specific justice. By fostering collaboration among governments, private enterprises, scientific institutions, and international bodies, this bottom-up approach cultivates a collective commitment to preserving the integrity of outer space. For instance, initiatives like the Artemis Accords are founded upon individual nations' agreement to cooperate and share resources. Ultimately, this collaborative approach can encompass diverse forms of resource development and mitigation strategies for addressing space debris.

4. Decentralized Governance Model and Institutional Innovation

As previously discussed, the protection of the outer space environment necessitates innovative governance methods. This section will analyze the constraining factors within the existing legal treaty system governing outer space, considering the role of soft law, international legal precedents,

18 Rossana Deplano, The Artemis Accords: Evolution or revolution in international space law?, International & Comparative Law Quarterly, Volume 70, Issue 3, July 2021, pp. 799-819.

19 Danilenko (n 18), pp. 181.

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references to national practices, and exploring the potential establishment of specialized courts or arbitration mechanisms to address environmental resource issues in outer space within the current legal framework.

4.1. Constraints of the Existing Treaty System of Space Law

Before delving into the aforementioned decentralized governance models and institutional innovations, it is imperative to evaluate the existing legal frameworks and provisions within the realm of outer space law.

4.1.1. Limitations of the Current Space Treaty Regime

The current regime of legal treaties governing outer space activities, including the Outer Space Treaty and its related agreements, is widely recognized as the fundamental framework for regulating space exploration. However, as previously discussed, this outdated legal framework exhibits inherent weaknesses that hinder its effectiveness in addressing contemporary challenges on environmental preservation in outer space. These treaties were established during the early stages of space exploration with a primary focus on promoting peaceful use and preventing militarization. Nevertheless, they lack comprehensive provisions addressing environmental protection concerns, clear delineation of responsible actors, and guidance on legal responsibilities and claims.

4.1.2. Outer Space Governance Process Based on Soft Laws

Soft law instruments offer a flexible and efficient mechanism for the establishment, bypassing prolonged debates over contentious terminologies and definitions.[20] In the context of outer space activities, soft law frameworks guide responsible behavior, promoting inclusivity by promptly adapting to evolving environments and fostering collaboration among diverse stakeholders. The transition towards soft law signifies a significant institutional innovation in safeguarding the outer space environment.

Due to its inherent flexibility, soft law emerges as the most appropriate regulatory instrument for governing outer space environments. The space community demonstrates heightened sensitivity and compliance towards quasi-ethical principles embedded within soft laws compared to legally binding agreements involving administrative functions or sanctions. Soft laws are widely recognized, accepted, and informally respected by countries under treaty law; despite being non-binding, they hold universal persuasive influence. Considering the limited international acceptance of hard law treaties among nations alongside rapid technological advancements and fierce commercial competition in space activities, there is an observable transition

20 Mahir Al Banna, Can Soft Law Regulate Outer Space Activities?, 125 J.L. Pol'y &Globalization 56 (2022), pp. 56.

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from treaty-based regulations towards soft law norms that effectively embody practical implementation.[21]

For example, let us consider the 'Transparency and Confidence-Building Measures for Outer Space Activities.' In recent years, Russia has prioritized the field of outer space law and proposed a series of initiatives. Significantly, Russia's dedication to promoting transparency in outer space activities and implementing confidence-building measures gained support from 178 countries.[22] The Russian Federation foresees that the proposed international legal instrument entitled the 'Treaty on Preventing the Placement of Weapons in Outer Space and Prohibiting the Use of Force against Objects in Outer Space,' initiated by China, Russia, and other nations will constitute a pivotal stride towards ensuring space security. Participating countries commit to refraining from deploying any type of armament in outer space.[23]
In the realm of soft law implementation, numerous initiatives have been proposed to tackle emerging concerns regarding environmental protection in outer space.[24] A noteworthy recent instance is the formulation of Space Debris Mitigation Guidelines within the framework of the Inter-Agency Space Debris Coordination Committee (IADC), subsequently endorsed by the United Nations General Assembly after 2007.

4.2. Revisiting Precedents on Environmental Protection in Existing International Legal Frameworks

For example, tracing back to 1962, a former Soviet satellite crashed in the United States. Subsequently, in December 1977, a Soviet nuclear-powered satellite disintegrated over northern Canada, dispersing radioactive debris across an area approximately equivalent to Austria's size due to partial debris fallout from the aforementioned Soviet satellite incident. As per the Liability Convention's Article 12, on April 2, 1981, the Soviet Union agreed to provide compensation amounting to 3 million Canadian dollars for this occurrence.[25] If the satellite had landed in a more densely populated region within Canada, the liability borne by the Soviet Union would have been greater. The compensation paid by the Soviet Union was aimed at restoring Canada's situation as it would have been if no damage had occurred.[26] In this particular instance and considering causality factors, rather than

21 Mahir Al Banna, Can Soft Law Regulate Outer Space Activities?, 125 J.L. Pol'y &Globalization 56 (2022), pp.56.
22 Celebrating the Space Age: 50 Years of Space Technology, 40 Years of the Outer Space Treaty - Conference Report, 2-3 April 2007 (2007), pp.47-48.
23 Celebrating the Space Age: 50 Years of Space Technology, 40 Years of the Outer Space Treaty - Conference Report, 2-3 April 2007 (2007), pp. 48.
24 M. G. Marcoff, Traite de Droit International Public de l' Espace, Fribourg Editions Universitaires, 1973. At 290.
25 Benko, et. al., Space Law in the United Nations (Nijhoff, Dordrecht, 1975), para. 51, 96.
26 Liability Convention, Art. 12.

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compensating solely at its occurrence site, the strategic approach of compensating for the precise location of damage was adopted by the Soviet Union to restore and rectify adverse impacts inflicted upon outer space environment.

4.3. Establishment of a Specialized Court or Arbitration Body for Environmental Resources

The governance model for protecting the outer space environment is continuously evolving, with a strong emphasis on international cooperation, transparency, and adherence to best practices. Currently, innovative approaches to governance are being explored, including the utilization of soft law instruments and delegation of authority to effectively adapt to the dynamic nature of space activities. Meanwhile, establishing a dedicated judicial mechanism for the environmental sector of outer space law requires careful considerations such as international cooperation, financial support, and independent and transparent operation, among other crucial factors. International collaboration plays a pivotal role in ensuring the legitimacy and authority of this institution. Moreover, securing adequate funding is essential for sustaining this judicial mechanism - whether it takes the form as a specialized court or arbitration institution. Therefore, engaging in negotiations regarding financing and maintenance strategies for such an entity becomes imperative for the international community. Potential sources of funding may include contributions from member states, support from international organizations, and other viable financial mechanisms. Last but importantly as a judicial institution maintaining independence is crucial in effectively fulfilling its duties; thus transparency serves as a cornerstone in fostering trust and guaranteeing a fair judicial process.

5. Conclusion and Prospects

With the increasing commercialization of space activities, such as satellite deployment and resource development, ensuring the long-term sustainability of these endeavors and mitigating their detrimental impact on the outer space environment has become an indispensable aspect of human sustainable development. Despite encountering various challenges, humanity has recognized the paramount significance of safeguarding the space environment and is actively fostering international collaboration. Notably, international organizations like the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) have established a platform that facilitates global cooperation and diplomatic negotiations. As previously elucidated, the international community must revise and strengthen existing legal frameworks and regulations to overcome inherent limitations, thereby effectively addressing concerns related to space debris, pollution, and weather phenomena. This endeavor necessitates collective efforts from all nations to

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ensure meticulous consideration for environmental preservation. Simultaneously, beyond governmental entities, an increasing number of individuals are becoming aware of the urgency surrounding outer space environmental conservation; this signifies their potential to stimulate actions by both governments and private sectors aimed at safeguarding our celestial surroundings. Consequently, future advancements in space activities will place heightened emphasis on sustainability and responsibility.