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Human Rights Implications of Space Debris: A Legal Study of Sustainability, Liability and Access to Essential Satellite Services

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Abstract

The problem of space debris is a significant issue for sustainable governance of outer space. Earth is increasingly crowded with satellites, commercial space operations, and private participation which is also giving rise to collision risks. While space debris is usually perceived as a technical, environmental or operational problem, its human rights aspect needs to be studied. Satellites are used to assist various activities and services, including telecommunications, navigation, meteorology, climate services, disaster management, Internet access, agriculture, banking, telemedicine and the response to emergencies. The interruption of these satellite dependent services can impact the right to life, health, access to information, communication, livelihood, equality and environmental protection for vulnerable and remote communities, among others. The research methodology used in this paper is doctrinal in nature, which is qualitative based from secondary sources such as International Treaties, UN Guidelines, Indian Policy documents, Scopus Indexed literature, and Institutional Reports. It explores the links between space debris, sustainability, liability and access to vital satellite services. The paper concludes that the existing framework is still very much state-centric, object-centric and relies on 'voluntary mitigation norms'. It calls for a governance framework for space debris which is based on prevention, accountability, compensation, transparency, space traffic coordination and intergenerational equity, and is rights-sensitive and sustainable.

Keywords: Space Debris, Human Rights, Sustainable Space Governance, Satellite Services, Space Liability and Outer Space Law.

1. Introduction

The sky is not the limit anymore as outer space is now used for scientific research, defence and strategic communication. It is now a crucial technological asset in today's life. Satellite systems are used for communication networks, weather forecasting, navigation, disaster management, environmental monitoring, agriculture, banking, telemedicine, internet connections and emergency responses[1]. As a result

[1]Simonetta Di Pippo, "The Contribution of Space for a More Sustainable Earth: Leveraging Space to Achieve the Sustainable Development Goals" 2 Global Sustainability art. e3 (2019).

the safety of the orbital activity is now closely tied to the protection of public welfare and human rights on Earth[2].

Space debris is one of the foremost dangers to the safety of the orbit. Space debris consists of objects in earth orbit that are no longer functioning, such as spent rocket stages, defunct satellites, fragments from explosions, pieces of old satellites and mission debris[3] . These objects have very high velocity and can cause damage to spacecraft and satellites in operation[4]. Kessler and Cour-Palais (1978) cautioned that artificial objects could create additional fragments in a future collision that would increase the likelihood of future collisions. Debris regulation has become a major issue for sustainable space operation in the long term, due to this cascading risk[5].

This paper identifies the research problem: Existing space law frameworks are not well developed enough to provide for human rights impacts created by disruption of services in cases of debris[6]. The regime in international law is primarily focused on physical damage and State-to-State claims and is based on State responsibility and liability for space objects. It is inadequate to deal with the indirect damage to people and communities from the interruption of services provided by satellites[7]. This is important as satellite failure may impact disaster warnings, emergency communication, environmental monitoring, financial transactions and access to information.

There are gaps in the integration of human rights analysis in space debris governance. Debris has been the subject of existing scholarship both from a scientific and technical and from an environmental and international legal perspective. Comparatively much less focus, however, has been paid to the impact of debris related disruption of satellite services on rights like the right to life, health, communication, equality, livelihood and environment protection[8]. The present paper therefore explores space debris as an issue of law and human rights.

This study aims at analysing the nature of space debris, understanding how space debris is connected to human rights, evaluating the effectiveness of extant international and Indian laws, and ultimately identifying the lacunas in the legal regimes and suggesting a rights-based approach towards sustainable governance of space debris. It is an original contribution to the literature that brings together space law, environmental sustainability and liability, and protection of human rights[9].

2. Literature Review

The scientific knowledge of space debris and orbital collision risk is the starting point of literature research on space debris. Kessler and Cour-Palais (1978) have provided an explanation for how an ever-increasing number of objects in orbit could create a self-reinforcing debris environment[10]. Liou and Johnson (2006) also concluded that debris in Earth orbit presents significant risk to operational spacecraft and that

[2] Danielle Ireland-Piper and Steven Freeland, "Human Rights and Space: Reflections on the Implications of Human Activity in Outer Space on Human Rights Law" 9 Groningen Journal of International Law 101 (2021).
[3] Abid Murtaza, Syed Jahanzeb Hussain Pirzada, et.al., "Orbital Debris Threat for Space Sustainability and Way Forward" 8 IEEE Access 61000 (2020).
[4] J.-C. Liou and N.L. Johnson, "Risks in Space from Orbiting Debris" 311 Science 340 (2006).
[5] Christopher J. Newman and Mark Williamson, "Space Sustainability: Reframing the Debate" 46 Space Policy 30 (2018).
[6] supra note 2.
[7] Peter Stubbe, State Accountability for Space Debris: A Legal Study of Responsibility for Polluting the Space Environment and Liability for Damage Caused by Space Debris (Brill Nijhoff, Leiden, 2018)..
[8] supra note 2
[9] Ibid.
[10] D.J. Kessler and B.G. Cour-Palais, "Collision Frequency of Artificial Satellites: The Creation of a Debris Belt" 83 Journal of Geophysical Research: Space Physics 2637 (1978).

sustainable solutions to the long-term problem of orbital debris necessitates action to prevent and remove debris[11]. These studies support the science underpinning the Debris as a Systemic Risk model, as opposed to an operational issue.

This worry has been growing in recent technical literature. Murtaza et al. (2020) examined the causes, threats and mitigation of orbital debris, noting the importance of the debris accumulation on the usefulness of satellite technology[12]. Similarly, Bennett (2025) believes that orbital debris should be prevented and mitigated throughout the satellite life cycle, encompassing pre-launch design, operation and end-of-life disposal[13]. The works demonstrate the need for embedding debris management into the full mission cycle.

The sustainability dimension has been proposed by Newman and Williamson (2018), who contend that space sustainability is "the need to rethink governance systems for space that are limited to technical regulation"[14]. Morin and Richard (2021) define astro-environmentalism, and orbital space as a common-pool resource that can be polluted and overused[15]. Rao et al. (2020) introduce an economic aspect by presenting an argument for the inclusion of an economic cost of congestion that can be internalised through the implementation of orbital-use fees, which can enhance the long-term value of the industry[16]. The studies' observations collectively indicate that space debris is a sustainability, governance and collective-action problem.

Legal scholarship has focused on state responsibility, liability, and remediation. Popova and Schaus (2018) examine the legal framework for active debris removal and identify issues of jurisdiction, ownership, consent, and liability[17]. Zannoni (2022) argues that general international law and UN-COPUOS debris mitigation guidelines may help tackle debris proliferation, but the current system still has limitations[18]. Stubbe (2018) offers a doctrinal account of state accountability for space debris, distinguishing responsibility for wrongful conduct from liability for damage[19].

The literature on satellites is also applicable. Le Cozannet et al. (2020) illustrate the critical role of space-based Earth observations in disaster risk management, especially in terms of hazard assessment and disaster response[20]. Similarly, space science and applications, technology and services for agriculture, tele health, protection of biodiversity and disaster management have been shown to be related to sustainable development by Di Pippo[21] . This literature is significant as it brings the attitude of satellites and interests related to rights into relation with life, health and access to information.

[11] supra note 4.
[12] supra note 3.
[13] M.M. Bennett, "Orbital Debris Requires Prevention and Mitigation Across the Satellite Life Cycle" 4 Communications Engineering art. 95 (2025).
[14] supra note 9.
[15] Jean-Frédéric Morin and Benjamin Richard, "Astro-Environmentalism: Towards a Polycentric Governance of Space Debris" 12 Global Policy 568 (2021).
[16] Akhil Rao, Matthew G. Burgess, et.al., "Orbital-Use Fees Could More Than Quadruple the Value of the Space Industry" 117 Proceedings of the National Academy of Sciences of the United States of America 12756 (2020).
[17] Rada Popova and Volker Schaus, "The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space" 5 Aerospace art. 55 (2018).
[18] UN Committee on the Peaceful Uses of Outer Space, Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space, UN Doc A/62/20 (2007).
[19] supra note 7.
[20] G. Le Cozannet, M. Kervyn, et.al., "Space-Based Earth Observations for Disaster Risk Management" 41 Surveys in Geophysics 1209 (2020).
[21] supra note 1.

But, according to the literature reviewed there was a gap known. The discussion on debris risk and sustainability and liability has been provided by existing studies, but space debris has not been considered as a human rights issue. This paper aims to address that gap by looking at the impact of the disruption of satellite dependent service on rights, and developing a law oriented towards sustainability.

3. Methodology

Based on Secondary sources and qualitative, doctrinal and analytical research method, this study is conducted. It does not rely on empirical fieldwork, surveys or quantitative modelling . Rather, it focuses upon international treaties, UN guidelines, Indian policy instruments, peer-reviewed journal articles, and books, institutional reports and official documents relevant to outer space law and human rights law and sustainable space governance.

The doctrinal method is used to analyse legal instruments such as the Outer Space Treaty, 1967, the Liability Convention, 1972, the Registration Convention, 1975, the UN-COPUOS Space Debris Mitigation Guidelines and the Long-Term Sustainability Guidelines. The paper explores the Indian Space Policy, 2023, IN-SPACe Norms, Guidelines and Procedures, 2024, and India's Debris Free Space Missions 2030 initiative in the Indian context. These instruments are evaluated to see that they are adequate to cover debris mitigation, liability, private-sector supervision and disruption to satellite services.

The literature is analyzed using thematic analysis that categorizes it under five themes: scientific risk of space debris, sustainability of orbital space, international responsibility and liability, access to essential satellite services and implications for human rights. The analysis takes an interpretative approach as space debris is recognized not only as an engineering problem but also as a legal one in the context of public welfare. The scope is restricted to legal and policy analysis, the technical considerations of debris tracking and removal are limited to only as much as is necessary to be able to define the legal problem.

As shown in Figure 1, the research design combines doctrinal analysis with thematic interpretation.

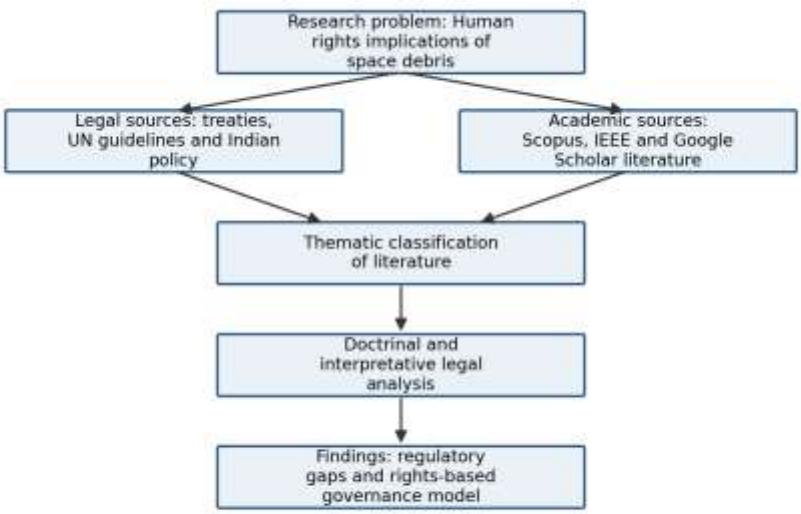

Figure 1. Methodological Framework of the Study

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Source: Author's own construction.

4. Results and Discussions

The first is the space debris poses a rights-relevant risk, since satellites are now an integral part of important public services. A collision with debris can inflict physical damage on a satellite, but the impacts can also be on communications, navigation, weather, disaster warning and emergency response, and environmental monitoring[22]. These services are connected with human rights such as life, health, information, communication, livelihood and equality . It is likely to be more significant for rural, remote, coastal, mountainous and disaster-prone communities that are highly reliant on satellite-based services where terrestrial based infrastructure is lacking[23].

The second discovery is that the existing international framework is still largely state centric and object-centric. Outer Space Treaty Article VI states that the State is responsible for national space activities, which includes non-governmental space activities[24]. The rules for damage caused by space objects are given by the Liability Convention. However, these rules were framed during a period when space activities were mainly State-controlled[25] . Private operators and commercial constellations are important today. This makes it difficult to attribute the work to the desired author, and to oversee it, as well as to obtain insurance or liability coverage. There is no clarity in the current framework on the indirect human rights harm arising out of the disruption of satellite services [26].

The third result is that the norms of debris mitigation are frequently "soft norms". The UN-COPUOS guidelines and the long-term sustainability principles are of importance but only effective if implemented nationally. If there is no legally binding domestic legislation, the level of mitigation could be low. This is especially true of India[27]. India has embraced the Indian Space Policy, 2023 and IN-SPACe authorisation guidelines, and has declared a Debris Free Space Missions 2030 initiative[28]. While these are positive developments, a comprehensive national space law is still needed in India to transform the commitments in policy into obligations.

The fourth finding is on liability and compensation. The indirect harm is best handled by existing space liability law, which is geared toward direct harm. The satellite owner can be the immediate claimant in case of damage to the satellite[29]. But the impacted community may not have a remedy in case of disruption of disaster warning, telemedicine, communication or navigation. The resulting disparity between damage to space objects and the consequences of failures of satellite services to the public[30]. This relationship between orbital debris, disruption of satellite services and rights-based consequences is illustrated in Figure 2.

[22] supra note 20.
[23] Ibid.
[24] The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967, art. VI.
[25] Diego Zannoni, “Out of Sight, Out of Mind? The Proliferation of Space Debris and International Law” 35 Leiden Journal of International Law 295 (2022).
[26] supra note 2.
[27] Kumar Abhijeet, “Development of National Space Law for India” 14 Astropolitics 185 (2016).
[28] supra note 7.
[29] Rada Popova and Volker Schaus, “The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space” 5 Aerospace art. 55 (2018).
[30] supra note 7.

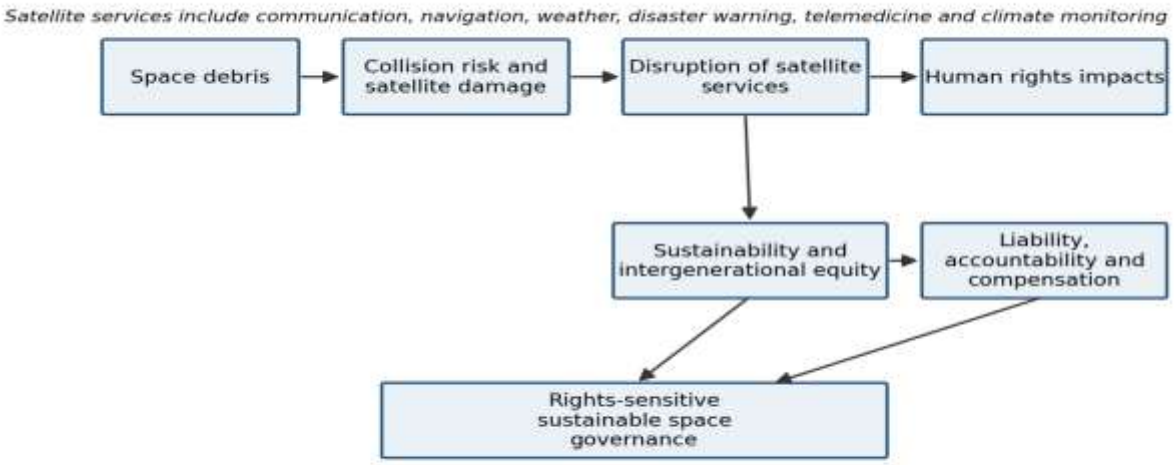

Figure 2. Conceptual Framework Connecting Space Debris and Human Rights

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Source: Author's own construction based on reviewed literature.

The fifth finding is India's policy framework is on the right track and needs to be statutorily strengthened. IN-SPACe has the potential of making a significant contribution to authorisation and supervision, but it should be complemented by new legislation that sets out provisions for debris mitigation, mission-life-cycle supervision, insurance requirements, including post-mission disposal, active debris removal, data sharing and penalties for non-compliance[31]. This is particularly significant as India is promoting private sector involvement in space activities.

The sixth discovery is that law uncertainty is raised due to the lack of a global space traffic management regime. With increasing number of satellites, there is a need for guidance on conjunction warnings, manoeuvre coordination, priority of manoeuvres, and consequences of not following through on a credible alert for a conjunction. If there were no such rules, avoiding collisions would be dependent on inconsistent operator behaviour. If a rights based approach is adopted, space traffic management is not just a technical necessity, but also a part of the responsibility to secure the provision of essential satellite services[32].

The next finding is that human rights law could add richness to space governance. Space law is traditionally about States and space objects, while human rights law is about people, communities and remedies. A combined approach would involve preventive responsibilities, transparency, accountability and special attention to vulnerable communities. Not every failure of a satellite to make it to orbit is a human rights violation[33] . Instead, it is about the public interest dimension of debris prevention being acknowledged by legal frameworks where satellite services are a life-saving necessity, disaster safety, health, communication or access to information is concerned[34]. The main international and national regulatory gaps identified by the study are presented in Figure 3.

[31] supra note 7.
[32] P.J. Blount, "Space Traffic Coordination: Developing a Framework for Safety and Security in Satellite Operations" 2021 Space: Science & Technology art. 9830379 (2021)..
[33] supra note 2.
[34] supra note 20.

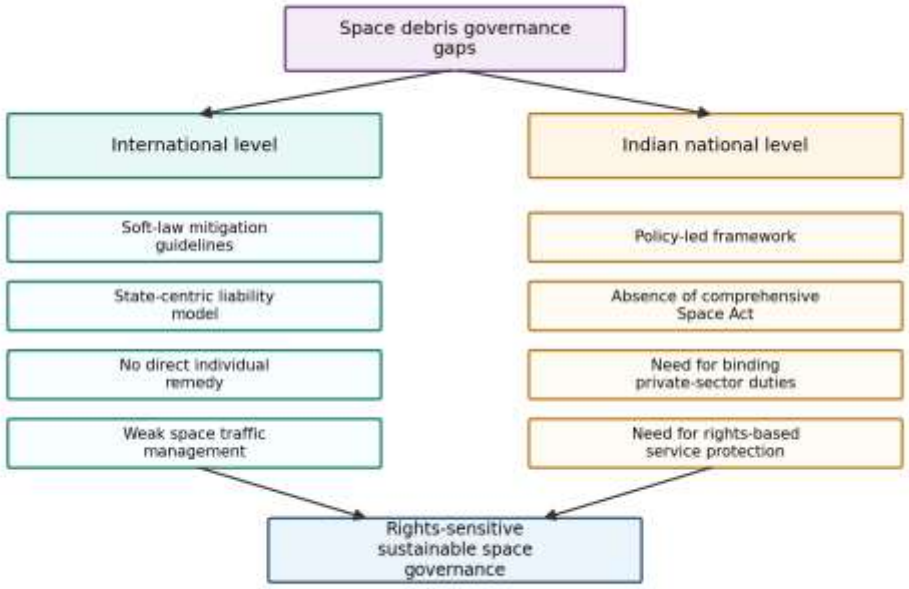

Figure 3. Regulatory Gap Matrix in Space Debris Governance

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Source: Author's own construction.

5. Conclusion

The problem of space debris is not only a technical one in outer space. It's a sustainability, responsibility and human rights issue. A growing reliance by modern societies on the use of satellites for various services makes it possible that debris issues can impact communication, disaster management, health, environmental monitoring, navigation, livelihood and access to information. Thus, the protection of the orbital environment is directly related to public welfare on Earth.

Three key ways the current legal structure is deficient are identified in the study. First, international space law is still very much a State-centric approach and based on the concept of damage inflicted by space objects. Second, there are still strong reliance on voluntary guidelines and national level implementation that varies. Third, the issue of human rights in connection with disruption of the use of satellites is not explicitly addressed in space law. Such gaps are especially pertinent for India, where policy initiatives have spurred private involvement, but a thorough statutory structure remains to be developed.

The paper advances the scholarship by building a rights-based perspective to the governance of space debris. It calls for sustainable space governance to embed prevention and precaution, intergenerational equity, accountability of operators, compensation and protection of essential satellite services. Comparisons between national space laws of India, USA, European Union, Japan, Australia and the United Kingdom in the future could help to create more accurate legislative models. Additional studies could also include space traffic management with the use of AI; active debris removal and compensation mechanisms for disruption to satellite services.