Outer Space Pollution and Environmental Sustainability: A Constitutional and Human Rights Approach

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Abstract

Environmental sustainability has long been recognised as a constitutional and human rights imperative, but the discourse has largely remained confined to terrestrial ecosystems. With the rapid expansion of space exploration and commercial satellite activity, the issue of Outer space pollution caused by debris, defunct satellites, and unregulated exploitation has emerged as a critical environmental challenge of the 21st century. This paper explores the constitutional and human rights dimensions of outer space sustainability, with a focus on the Indian context. The Indian Constitution, through Articles 21, 48A, and 51A(g), establishes a robust framework for environmental protection, which can be interpreted expansively to include the cosmic environment. The right to life under Article 21, as judicially expanded by the Supreme Court, encompasses the right to a clean and healthy environment, thereby extending its relevance to space-based ecosystems that directly influence human survival on Earth through climate monitoring, disaster management, and communication systems. Additionally, the Directive Principles and Fundamental Duties enshrine a collective responsibility for safeguarding the environment, including new frontiers such as outer space. From a human rights perspective, outer space pollution undermines the rights to development, security, and intergenerational equity. Future generations are entitled to access and benefit from a sustainable space environment, echoing the principles of the "common heritage of mankind" under international law. India, as a signatory to the Outer Space Treaty (1967) and an emerging leader in space exploration, carries both a constitutional mandate and a moral obligation to advocate for global frameworks ensuring space sustainability. The paper concludes that addressing outer space pollution is no longer merely a technological challenge but a constitutional imperative and a human rights obligation. Integrating

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sustainability into space law and policy will ensure that humanity's pursuit of outer space remains equitable, safe, and just for present and future generations.

This paper aims to explore the intersection of outer space environmental protection, constitutional governance, and human rights. It emphasizes that the future of humanity and technological progress relies not only on exploring beyond Earth but also on preserving the cosmic environment for present and future generations.

Keywords*: outer space pollution, space debris, Kessler syndrome, space sustainability, common heritage of mankind, space debris mitigation, global commons.*

I. Introduction

Humanity's foray into outer space, once the realm of dreamers and visionaries, has become a bustling frontier of commerce, science, and geopolitics. From the Montgolfier brother's hot-air balloon ascent in 1783 to the Wright brother's powered flight in 1903,[2] and culminating in Sputnik-I's beeping signal on October 4, 1957, technological leaps have redefined our planetary boundaries. The Space Age dawned amid Cold War rivalries, leading to significant achievements such as Luna 9 landing in 1966 and Neil Armstrong setting foot on the lunar surface in 1969.[3] Yet, these triumphs sowed seeds of environmental peril. Each launch discards upper stages, expended boosters, and defunct payloads, accumulating as high-speed refuse in orbit.

Today, over 36,000 trackable objects orbit Earth, with only about 6% operational satellites; the rest 94% comprises inert debris hurtling at 28,000 km/h, capable of piercing spacecraft hulls like bullets.[4] The European Space Agency's 2025 report documents a 2024 surge: fragmentation from a Chinese

[2] Sandeepa Bhat B.(2008). The Legal Status of the Moon and other Celestial Bodies, Implications of the Concept of Common Heritage of Mankind (Doctrinal Dissertation), University of Mysore.

[3] Reeves, R. (1994). Russian Robots on the Moon. In The Superpower Space Race: An Explosive Rivalry through the Solar System (pp. 131-166). Boston, MA: Springer US.

[4] Haroun, F., Ajibade, S., Oladimeji, P., & Igbozurike, J. K. (2021). Toward the sustainability of outer space: Addressing the issue of space debris. New Space, 9(1), 63-71.

Shenzhou-15 re-entry and routine collisions added thousands of shards, outpacing natural atmospheric drag. Mega-constellations like SpaceX's Starlink, exceeding 6,000 satellites by 2025, perform millions of avoidance maneuvers annually, straining fuel reserves and hastening failures. Militarization exacerbates this, Russia's 2021 ASAT test generated 1,500 trackable fragments, forcing International Space Station (ISS) evasive actions.

For India, a rising space power with ISRO's Chandrayaan-3 lunar south pole landing in 2023 and Gagan Yaan crewed mission slated for 2026, these threats loom large. Space assets underpin disaster management (e.g., cyclone tracking via INSAT), agriculture (crop monitoring), and connectivity in remote areas. Pollution risks service disruptions, economic losses, and safety hazards from uncontrolled reentries, as seen in China's Long March 5B stages splashing near villages in 2020-2023.

Legally, space is the "province of all mankind" as per the Outer Space Treaty 1967 (OST), prohibiting national appropriation and mandating peaceful use. Article IX requires avoiding harmful contamination, while Article VI imposes state liability for private actors. The 1972 Liability Convention enforces compensation for damages. Yet, these frameworks, framed in a pre-commercial era, falter against today's deluge. Soft laws like UNCOPUOS, Long-term Sustainability Guidelines (2019) urge post-mission disposal but lack teeth.

India's Constitution offers fertile ground for extension. Article 21's right to life, judicially broadened to include a "healthy environment" (*Subhash Kumar v. State of Bihar,* 1991), encompasses space-derived benefits. Articles 48A and 51A(g) compel state protection and citizen duties toward nature. Human rights lenses—intergenerational equity, precautionary principle—frame space as a global public trust. The urgency is palpable: unchecked, debris cascades (Kessler Syndrome) could render low-Earth orbit (LEO) unusable by 2030, severing GPS, weather forecasts, and telecoms vital for billions.[5]

[5] ESA Space Environment Report 2025. (Apr. 1, 2025), (last visited Jan. 28, 2026) https://www.esa.int/Space_Safety/Space_Debris/ESA_Space_Environment_Report_2025.

II. Outer Space Pollution: Nature, Scale, And Emerging Threats

The conception of outer space as a pristine and infinite expanse gradually shifted once humanity began launching objects beyond Earth's atmosphere. With the beginning of the Space Age in 1957, space activities expanded at a pace unseen in earlier technological advancements.[6] The 20th century is marked by significant scientific milestones that fundamentally altered human interaction with space:

- **1783** – First hot-air balloon flight by the Montgolfier Brothers
- **1903** – Wright Brothers achieve the first powered aircraft flight
- **1957** – Launch of *Sputnik-I*, the first artificial satellite (Soviet Union)
- **1958** – *Explorer-I* launched by the United States
- **1966** – Soviet Luna 9 becomes the first spacecraft to land on the Moon
- **1969** – Apollo 11: Neil Armstrong becomes the first human to walk on the Moon

Initially, these advancements were viewed as feats of scientific innovation without environmental concerns. However, every mission left behind remnants, rocket bodies, detached boosters, broken satellite parts, which began accumulating over time. Since the launch of Sputnik-I, more than 8,400 space missions have taken place, placing nearly 21,000 human-made objects into orbit.[7] By 2025, the European Space Agency estimates:

- Nearly 6,500 artificial objects are orbiting Earth
- Only 6% are functioning satellites
- Total debris mass exceeds 2 million kilograms

Today, millions of smaller debris fragments remain undetectable, yet pose catastrophic collision risks due to their orbital velocity, nearly 28,000 km/hour.

[6] Gorove, S. (1972). *Pollution and outer space: A legal analysis and appraisal*. NYUJ INT'L L. & POL., 5, 53.

[7] J. N. PELTON, NEW SOLUTIONS FOR THE SPACE DEBRIS PROBLEM, (Cham: Springer International Publishing 2015).

A. Major Space Debris Incidents and Environmental Consequences.

Several events have emphasized how orbital debris threatens both space safety and terrestrial environments: [8]

Year	Incident	Nature of Harm
1978	Kosmos (Soviet Satellite)	Nuclear debris scattered over Canada
1969	Japanese ship damaged by falling space scrap	Hazard to human and property safety
1979	Skylab uncontrolled re-entry	Debris fell across Australia.
2019	SpaceX Starlin collusion warnings	Increased Collusion probability with ESA satellite
2021	Russian ASAT Test	Created thousands of debris fragments endangering ISS.
2020-2023	Chinese Long March 5B	Large rocket parts fell near populated regions.
2022-2024	Long March 5B	Uncontrolled falls near Maldives, Philippines; public outcry.
2024	Shenzhou-15	Breakup over Atlantic; seismic detection of impact
2025	Hypothetical Starlink cascade	Maneuvers overload projected.

Such cases reveal that space pollution does not remain in space, it directly threatens life, health and security on Earth.

B. Commercialisation, Militarisation, and the Growing Debris Risk

The rapid increase in satellite "mega-constellations" like Starlink, OneWeb, and Kuiper has added hundreds of new satellites each year. Astronomers warn these satellites are contributing to the following.[9]

[8] Lennquist, S., Major incidents: Examples and experiences. In Medical Response to Major Incidents and Disasters: A Practical Guide for All Medical Staff (pp. 9-32). Berlin, Heidelberg: Springer Berlin Heidelberg 2011.

- Light pollution, disrupting astronomical research
- Increased radio frequency congestion
- Heightened risk of collisions

The military dimension has also intensified, with nations testing anti-satellite (ASAT) weapons that produce highly destructive debris clouds.

C. The Kessler Syndrome and the Risk of Orbital Collapse

If collisions continue and debris multiplies uncontrollably, Earth's lower orbit could reach a Kessler Syndrome state where debris crashes generate more debris in a cascading chain reaction, potentially making certain orbits unusable, hindering space missions and satellite services and threatening global communication, navigation & weather systems.[10]

The Kessler Syndrome refers to a scenario in which collisions between satellites and space debris create a chain reaction, producing increasing amounts of debris that can make low Earth orbit (LEO) unusable. First proposed in 1978 by NASA scientists Donald Kessler and Burton Cour-Palais, the theory explains how debris growth can become self-sustaining once a critical density is reached.[11] Today, Earth's orbit contains tens of thousands of tracked debris objects, with millions of smaller fragments traveling at extremely high speeds. Incidents such as satellite collisions, anti-satellite weapon tests, and recent rocket breakups have significantly increased collision risks. Even small debris can cause catastrophic damage to operational satellites. The Kessler Syndrome threatens essential space-based services including navigation, communication, weather forecasting, and scientific research. Although mitigation measures such as debris-removal technologies, collision-

[9] Oses Astiz, M., *The Commercialisation of Space as an Information Source: An Enquiry into Potential Implications for Geospatial Intelligence*, 2023.

[10] Lehnert, C., Karlsson, E., & Giannopapa, C. (2017). Global risk & global challenges, Space as a Game Changer for Socio- Economic Sustainable Development. Acta Astronautica, 140, 59-65.

[11] Donald J. Kessler & Burton G. Cour-Palais, Collision Frequency of Artificial Satellites: The Creation of a Debris Belt, 83 J. Geophys. Res. 2637 (1978).

avoidance systems, and international guidelines exist, they remain largely non-binding.[12]

The increasing accumulation of space debris poses serious risks to satellites, human safety, and the long-term sustainability of Earth's orbits. Although the Outer Space Treaty (1967) does not expressly regulate space debris, Article IX introduces the binding principle of "due regard", requiring States to conduct space activities with consideration for the interests of others and to avoid harmful contamination. This principle can be understood as imposing responsibility on States to mitigate debris through preventive measures, consultation, and information sharing. Existing soft law instruments such as Space Debris Mitigation Guidelines, Long-Term Sustainability (LTS) Guidelines, and the Artemis Accords support this obligation by encouraging responsible mission planning, end of life disposal, and transparency.

D. Sustainability Imperatives and the Need for Legal Safeguards

Outer space has transformed from a place of opportunity to a fragile ecosystem requiring urgent protection. Legal, scientific, and governance frameworks must now evolve to prevent future debris generation. [13] Thus, the pollution of outer space illustrates a pressing shift from scientific progress to environmental and human rights concern, underpinning the need for strategic regulatory reforms. The ESA Space Environment Report 2025 highlights the growing congestion of Earth's orbit due to defunct satellites and debris.[14]

III. International Legal Framework for Sustainable Use of Outer Space

As the outer space is a global common, its governance is international in character. The foundational principle is that since the outer space is an international appropriation, all activities must be conducted for the welfare of all humankind. The United Nations plays a central role in shaping space governance through Committee on the peaceful uses of outer space (UNCOPUOS) and the UN Office for Outer Space Affairs (UNOOSA). These institutions promote cooperation, monitor compliance, and develop norms

[12] Kessler & Cour-Palais, *Collision Frequency of Artificial Satellites*, supra note 12

[13] Popova, R., & Schaus, V. (2018). The legal framework for space debris remediation as a tool for sustainability in outer space. Aerospace, 5(2), 55.

[14] European Space Agency, ESA Space Environment Report 2025, supra note 5

addressing new technological challenges such as debris mitigation and satellite mega-constellations.[15]

A. Key International Treaties Governing Outer Space

The international legal framework consists of five major UN space treaties which are as follows:

- The Outer Space Treaty 1967 often described as the **"**Constitution of Outer Space", it establishes: freedom of exploration and use of outer space by all States, prohibition of sovereignty or territorial claims in space, use of space exclusively for peaceful purposes.
- Liability Convention, 1972 - Imposes absolute liability for damage caused by space objects on Earth. Fault-based liability for damage caused in outer space This framework is significant in addressing collisions and debris-related harm, although practical enforcement remains limited.[16]
- Registration Convention, 1976
  Requires States to register all launched objects with the UN Promotes transparency, tracking of space objects, and improved debris monitoring.
- Rescue Agreement, 1968
  Rescue and safe return of astronauts
- Moon Agreement, 1979
  Moon Agreement emphasizes common heritage of mankind, but remains less adopted by major space powers

[15] Yan, Y. (2019). Maintaining long term sustainability of outer space activities: Creation of regulatory framework to guide the Asia-Pacific space cooperation organization and selected legal issues. Space Policy, 47, 51-62.

[16] Foster, W. F. (1973). The convention on international liability for damage caused by space objects. Canadian Yearbook of International Law/Annuaire canadien de droit international, 10, 137-185.

B. Soft Law Developments: Toward Sustainability

As binding treaties lack behind technological advances, soft law instruments have become crucial, including: -

- IADC Space Debris Mitigation Guidelines (2002)
- UNCOPUOS Guidelines for Sustainability of Outer Space Activities (2019) National best practices and codes of conduct.[17] These norms encourage responsible post-mission disposal, collision avoidance mechanisms, transparency and data sharing.
- UN Draft Resolution on Promoting Peaceful, Sustainable, and Cooperative Uses of Outer Space (2025) The 2025 UN outer space draft resolution on international cooperation emphasizes peaceful, sustainable, and inclusive use of outer space. The resolution promotes capacity-building, especially for developing countries, through programs like UN-SPIDER, regional education centers, and the Space and Global Health Platform. It supports international cooperation, regional organizations, private sector engagement, and the "Space2030" Agenda to harness space technology for sustainable development, disaster management, and global health. It also endorses observer status for new space organizations and reaffirms COPUOS governance and officer elections.[18]

C. Emerging Developments in Space Law

The European Union Space Act (2025) aims to establish a single EU market for space activities by regulating safety, resilience, and sustainability. It applies to EU and non-EU operators providing services in the Union and establishes the Union Register of Space Objects (URSO) for authorisation and supervision. Key measures include collision avoidance, debris mitigation, cybersecurity (NIS2), and environmental footprint declarations, while governance is shared between Member States, EUSPA, and the Commission, which can impose fines. The regulation excludes pre-2030 launches and military-only assets, and

[17] Martinez, P. (2020). The Role of Soft Law in Promoting the Sustainability and Security of Space Activities. J. Space L., 44, 522.

[18] U.N. Gen. Assembly, Draft Resolution, Int'l Cooperation in the peaceful uses of outer space, A/C.4/80/L.8, 80th Sess., 4th Comm., 1–49 (Oct. 24, 2025).

is designed to enhance EU strategic autonomy, industry competitiveness, and cross-border harmonisation, with application from 1 January 2030.[19]

India's space law evolution, showing a shift from sovereignty and strategic autonomy toward emerging environmental sustainability concerns. While international norms and practices from the US, EU, and China promote debris mitigation and accountability, India's legal framework relies on draft legislation and agency protocols with limited enforceability. Key gaps include the absence of binding national laws on space environmental protection and weak regulatory capacity. The study calls for a comprehensive legislative framework that embeds sustainability, strengthens oversight, and aligns India with international space standards.[20]

D. India's Approach to International Space Law

India is a signatory to four major space treaties - Outer Space Treaty (1967), Rescue Agreement (1968), Liability Convention (1972), Registration Convention (1976).[21] (except the Moon Agreement). Its growing commercial and strategic space profile has led to participation in UNCOPUOS driven sustainability initiatives, advocacy for equitable access, especially for developing nations. Increasing collaboration with global agencies through ISRO.[22] The recent legislative efforts signify movement toward regulated commercial and civilian involvement in space, aligning with global principles. India supports initiatives to prevent weaponization of space, promote equitable access for developing States, enhance long-term sustainability measures against debris hazards.

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[19] Clément Evroux, EU Space Act, EU Legislation in Progress, European Parliamentary Research Service (EPRS), PE 775.922 (Sept. 2025), https://www.europarl.europa.eu/thinktank/en/document/PE-775.922

[20] Savita Sharma & Tufail Ahmad Khan, From Sovereignty to Sustainability: Examining India's Space Law Trajectory with Comparative Insights on Environmental Degradation in Outer Space, DOI: https://doi.org/10.18848/96f33k23

[21] Hussain, S., & Shahzad, K. (2023). India's quest for 'global space and influence'through the 'outer space'domain. Journal of Space Safety Engineering, 10(3), 351-365.

[22] Matton, E. (2023). Avoiding the Kessler Effect: An Evaluation of the International Regulation of Space Debris.

E. Challenges in International Governance

Despite the robust legal structure, several gaps persist like the lack of binding debris mitigation standards, no established liability for environmental damage to outer space, no sufficient enforcement mechanisms for non-State actors, militarization concerns due to dual-use technologies. These challenges necessitate stronger constitutional and human rights perspectives to ensure sustainability and peaceful use of space.[23]

IV. India's Constitutional Mandate for Outer Space Protection

Environmental protection in India is deeply rooted in constitutional jurisprudence. Although the Constitution did not originally include explicit environmental rights, judicial expansion and constitutional amendments have affirmed environmental sustainability as a fundamental right and state responsibility.[24]

Key provisions applicable to outer space environmental protection:

- Article 21: Right to life includes the right to a clean, healthy, and safe environment.
- Article 48A (Directive Principle): State shall protect and improve the environment.
- Article 51A(g): Fundamental duty of citizens to protect and improve the natural environment,

Judicial interpretation extends these protections beyond geographical boundaries when environmental harm directly or indirectly impacts human life. Space-based environmental protection supports climate monitoring, communication networks, defense preparedness, and disaster response, thus reinforcing its constitutional relevance.

A. Relevance of Environmental Jurisprudence to Outer Space

The Supreme Court has repeatedly upheld ecological preservation, principles which are analogously applicable to outer space: polluter pays principle,

[23] R. S., JAKHU, & J. N. PELTON, (EDS.). GLOBAL SPACE GOVERNANCE: AN INTERNATIONAL STUDY (pp. 205-229). Cham: Springer, 2017.

[24] G. S. SACHDEVA, OUTER SPACE: LAW, POLICY AND GOVERNANCE: LAW, POLICY AND GOVERNANCE, (KW Publishers Pvt Ltd. 2013)

precautionary principle, sustainable development, intergenerational equity etc. Outer space debris poses future environmental risks, reflecting the need to apply these doctrines globally to ensure equity for future generations.[25]

B. Principles Derived from Environmental Jurisprudence

Several doctrines developed by Indian courts are applicable to space environmental governance.

- **Precautionary Principle** — Established in *Vellore Citizens Welfare Forum v. Union of India (1996)*; preventive action must be taken even without full scientific certainty.
- **Polluter Pays Principle** — Those responsible for pollution must bear remediation costs.
- **Public Trust Doctrine** — *M.C. Mehta v. Kamal Nath (1997)* held that resources essential to life must be preserved for the public.

Applying these doctrines to outer space ensures that States and private actors are held accountable for debris generation.

C. ISRO's Role in Sustainable Space Operations

The Indian Space Research Organisation (ISRO) has adopted responsible space practices: - Strict end-of-life disposal procedures - Orbit raising or controlled re-entry of satellites - Design changes to minimize fragmentation risks - Tracking and monitoring space objects in collaboration with global data-sharing systems[26]

Examples: - GSAT-12 decommissioning (2022) in accordance with UN guidelines. Controlled re-entry of RISAT-2 (2023) to avoid space debris buildup

These reflect India's commitment to international soft law debris mitigation standards.

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[25] Baker, H. A., The Application of Emerging Principles of International Environmental Law to Human Activities in Outer Space, (1996).

[26] S. Abraham, T. Balaji, & S. Renjith, (2017). *Sustainable Environment: Practices in Indian Space Research Organization-A Case Study.* INDIAN JOURNAL OF SCIENCE AND TECHNOLOGY, 10(18), 1-8.

D. Expansion of Article 21: Right to Pollution-Free Outer Space

The Indian Supreme Court has reiterated that the right to life under Article 21 includes the right to live a clean and pollution free environment. Landmark rulings provide constitutional grounding for protecting outer space as humanity's ecological interests.[27]

- ***Subhash Kumar v. State of Bihar (1991)*** - The Court interpreted that Article 21 includes access to pollution-free air and water.
- ***MC Mehta v. Union of India (1987 and series of cases)*** - The Court clarified the State's duty to prevent environmental hazards.
- ***Virender Gaur v. State of Haryana (1995)*** – The court upheld that environmental protection is an integral component of the right to life.

These cases collectively support the view that protection of environment extends to all domains affecting human well-being, including outer space activities.

E. Limitations in Current Constitutional and Legal Regime.

Despite constitutional commitments, gaps persist, there is no explicit legislation regulating private space entities, ambiguity in liability for debris-related damage, insufficient guidelines for environmental due diligence in space missions, emerging militarization concerns not fully addressed.[28] A stronger, codified framework aligned with human rights and sustainability goals is necessary.

V. Judicial Precedents and Case Law Analysis

Space law jurisprudence is still developing, and there are limited direct judicial rulings on outer space pollution. However, a strong foundation emerges from environmental and human rights case law, both internationally and within

[27] Meggiolaro, M. (2025). A New Policy Framework for Resource Extraction and Property Rights in Outer Space (Doctoral dissertation, Politecnico di Torino).

[28] G. ODUNTAN, SOVEREIGNTY AND JURISDICTION IN AIRSPACE AND OUTER SPACE: LEGAL CRITERIA FOR SPATIAL DELIMITATION. Routledge 2011.

India.[29] Courts have consistently recognized that environmental degradation threatens fundamental rights.

A. International Cases and Legal Incidents Relevant to Space Pollution

Although no major international court or tribunal has yet directly adjudicated a dispute specifically concerning space pollution, few cases and diplomatic claims have nonetheless played an important role in shaping the normative landscape of space law. In *Nemitz v. NASA (United States, 2004*), a private individual asserted ownership rights over an asteroid and sought compensation from NASA for alleged trespass. The claim was dismissed, with the court implicitly affirming the non-appropriation principle enshrined in Article 2 of the Outer Space Treaty. While the case did not concern space debris as such, it confirmed the limited scope for private property claims and highlighted the absence of private rights-based remedies under international space law, an issue that resurfaces in the debris context.[30]

More recently, this gap has been brought into sharper focus by *Alejandro Otero v. NASA (United States, 2024, ongoing). Alejandro Otero v. NASA (United States, 2024) - Space Debris Incident.* The problem of space debris gained legal significance when debris from the International Space Station (ISS) damaged the home of Alejandro Otero in Florida. The fragment, weighing about 0.7 kg, originated from a cargo pallet of old batteries released into orbit in 2021.[31] Mr Otero's claim raised an important legal question regarding liability for damage caused by space objects on Earth. The international space law governs such incidents through the Outer Space Treaty and Liability Convention, which impose absolute liability on the state launching the satellite, for damage caused

[29] Santhosh, S. (2022). *A Critical Analysis on the Applicability of" Doctrine of Temporary Presence" on Outer Space Objects-An Exception to Patent Infringement.* Issue 2 INDIAN JL & LEGAL RSCH., 4, 1.

[30] Yannick Radi, Clearing up the Space Junk: On the Flaws and Potential of International space law to Tackle the space debris problem, 12 ESIL Reflections, no. 2 (Mar. 9, 2023)

[31] Cranfill Sumner LLP, Mica Nguyen Worthy Submits First-of-its-Kind Claim to NASA Seeking Recovery From Damages Sustained from Space Debris (June 21, 2024), https://www.iadclaw.org/mica-nguyen-worthy-submits-first-of-its-kind-claim-to-nasa-seeking-recovery-from-damages-sustained-from-space-debris/

on Earth, irrespective of fault. However, this liability applies only between States and not to individuals.[32]

Although NASA carried out the operation, the debris was registered to Japan under the Registration Convention, making Japan the launching State for the purpose of international liability. In practice, however, individuals face difficulties in obtaining compensation, as claims must proceed through domestic courts or diplomatic channels. The Otero incident exposes a major gap in the existing liability regime, particularly the absence of a direct mechanism for individual compensation. With increasing space activities, the need for clearer legal frameworks and effective compensation mechanisms has become essential. These events reveal enforcement gaps regarding debris responsibility and preventive duties.

Although few disputes have formally reached adjudication, notable space incidents reflect legal challenges:

- Cosmos 954 Incident (1978): Canada claimed damages from the USSR after a satellite with a nuclear reactor fell over Canadian territory, handled under the Liability Convention claims procedure.[33]
- Iridium 33 vs. Cosmos 2251 Collision (2009): A major orbital collision highlighting absence of clear fault determination mechanisms - Kessler Syndrome Risk Recognition: Theoretical but widely acknowledged scenario of cascading collisions due to debris accumulation, influencing regulatory urgency.[34]

At the international level, the most prominent precedent remains the Cosmos 954 incident of 1978. Following the uncontrolled re-entry of a Soviet nuclear-powered satellite over Canadian territory, Canada brought a diplomatic claim against the USSR under the Liability Convention. The dispute was resolved through a settlement in which the Soviet Union paid

[32] *Id*.

[33] Cohen, A. F. (1984). *Cosmos 954 and the international law of satellite accidents.* YALE J. INT'L L., 10, 78.

[34] National Research Council, Division on Engineering, Physical Sciences, Aeronautics, Space Engineering Board, & Committee for the Assessment of NASA's Orbital Debris Programs. (2011). Limiting future collision risk to spacecraft: an assessment of NASA's meteoroid and Orbital Debris Programs. National Academies Press.

approximately three million US dollars in compensation. This episode remains the clearest practical application of the Convention's regime of absolute liability for damage occurring on the surface of the Earth, and it confirms that re-entering space debris can indeed trigger state responsibility. However, the case also illustrates the limitations of the existing system: resolution occurred through diplomacy rather than adjudication, environmental harm as such was not independently compensated, and the precedent has never been tested before an international court.

Taken together, these cases and claims reveal a fragmented and incomplete practice. They confirm core principles such as non-appropriation and absolute liability, while simultaneously exposing significant enforcement gaps, particularly with respect to private victims, environmental damage per se, and debris-related harm occurring in outer space. In the absence of international adjudication, norms continue to evolve indirectly through domestic courts, diplomatic settlements, and technical guidelines, reinforcing the need for clearer and more comprehensive legal mechanisms to address space debris pollution.

B. Global Common Resources and Intergenerational Justice

- **Advisory opinion on the environment and human rights (IACtHR, 2017)** -Established that environmental harm beyond borders violates human rights.
- **ICJ Advisory Proceedings on Climate Change (Pending, 2024)** — Expected to recognize future generation's rights to environmental protection.

Outer space sustainability aligns with these judicial trends by preserving "Common Heritage of Mankind" for future generations. As space activities increase every day, courts may be called upon to:

- Interpret constitutional protections to include outer space
- Enforce liability on private operators
- Prevent dangerous satellite launches without mitigation plans.
- Protect citizens from harms arising out of space re-entry or service disruptions

Judicial activism has historically expanded environmental rights in India; similar intervention could establish space environmental justice.

VI. Challenges in Enforcement and Accountability

Outer space pollution presents unprecedented enforcement challenges due to the global commons' nature of space and the limitations of current legal frameworks. First, the absence of a centralized international authority to regulate, monitor, and penalize offenders creates significant accountability gaps. States remain primarily responsible for activities carried out by non-governmental entities under their jurisdiction, as mandated by the Outer Space Treaty, yet private space actors have expanded rapidly with insufficient oversight.

Secondly, international space law lacks binding mechanisms for debris mitigation. Most guidelines, such as IADC recommendations and the UN COPUOS Space Debris Mitigation Guidelines are voluntary, resulting in fragmented and inconsistent compliance among nations. The principle of state sovereignty further restricts intrusive verification mechanisms, making it difficult to track responsibility for debris-causing incidents.

A third major hurdle lies in the attribution of liability. Under the Liability Convention, fault-based liability applies to in-orbit damage, but proving causation in collisions between fast-moving debris and satellites is technically complex. This creates loopholes where harmful conduct may go unaccounted for. Moreover, emerging activities like mega-constellations and active resource extraction raise novel governance questions not covered by existing treaties.

For India, the primary challenge stems from the lack of a comprehensive domestic space law that clearly defines environmental obligations, private sector accountability, and enforcement procedures. With private space enterprises expanding under the guidance of IN-SPACe, regulatory clarity is essential to prevent environmental negligence in space.

In sum, the enforcement deficit in outer space governance threatens long-term sustainability, making reform both urgent and unavoidable.

VII. Policy Recommendations and Way Forward

Ensuring a sustainable outer space environment requires a collaborative, multi-layered legal response. The following recommendations highlight the path forward:

1. Strengthening International Legal Frameworks
    - Advocate for a binding International Space Debris Treaty under the UN framework.
    - Introduce shared liability systems for commercial operators.
    - Develop global norms for responsible end-of-life satellite disposal.
2. Establishment of a Dedicated Global Space Sustainability Authority
    - Monitoring compliance using transparent, real-time tracking technologies.
    - Adjudicating disputes and imposing penalties for debris-causing activities.
3. India-Specific Legal Reforms
    - Enact a comprehensive National Space Law incorporating environmental sustainability, licensing protocols, and mitigation standards.
    - Mandate insurance and responsibility-sharing for private operators.
    - Encourage research into debris removal and eco-friendly fuel systems.
4. Technological and Scientific Interventions
    - Promote Active Debris Removal (ADR) technology development.
    - Use AI-driven tracking and collision-avoidance systems.
    - Foster green propulsion technologies and reusable launch systems.
5. Human Rights and Intergenerational Equity Safeguards
    - Integrate sustainability principles into national space missions.
    - Mandate environmental impact assessments for high-risk launches.
    - Ensure space development remains equitable for future generations.

By combining robust legal instruments with scientific innovation, global cooperation, and human rights-based governance, space sustainability can be better secured.

VIII. Conclusion

Outer space pollution poses a multidimensional threat technological, environmental, legal, and ethical. It undermines critical satellite services that support climate monitoring, navigation, communication, and national security. Most importantly, it limits the posterity to explore and benefit from outer space as a shared resource of humankind. While technological progress in space exploration has been rapid, legal frameworks have not evolved proportionately, resulting in regulatory gaps, weak enforcement, and increasing debris.

The Indian Constitution, particularly Articles 21, 48A, and 51A(g), establishes a robust constitutional basis for environmental protection. These provisions, when interpreted purposively, can be extended to encompass the protection of the outer space environment, given its direct and indirect implications for life, ecological balance, and long-term sustainability on Earth. Furthermore, judicially recognized doctrines such as the precautionary principle, intergenerational equity, and sustainable development strengthen this constitutional mandate by emphasizing prevention of harm, responsibility toward posterity, and balanced progress.

India's growing space capabilities place it at a decisive position to lead the global governance discourse on space environmental protection. There is now a pressing need for comprehensive national legislation on space sustainability, including provisions for licensing, liability, debris mitigation, and safe disposal. On the global level, binding enforcement mechanisms, collaborative debris removal missions, and shared responsibility frameworks must be established.

It is therefore evident that the challenge of outer space pollution is no longer a distant scientific concern but a constitutional, human rights, and global justice issue that demands immediate legal attention and cooperative international action.