
SPACE POLLUTION AND CHALLENGES FOR INDIA: SOCIO-LEGAL CONCERNS

Dr. Sandhya Balakrishnan, K.C. Law College, Mumbai, HSNC University

Introduction

Over the course of millions of years, humans have evolved into the most intellectually sophisticated species on the planet. Our cognitive capacities have been altered by both biological and cultural shifts, giving us a level of complexity and intelligence that is unmatched in the animal kingdom. Australopithecus and other early hominins were among the first to display characteristics that set the stage for higher intelligence. Because they walked erect, their early ancestors had more hands available for using tools and manipulating objects.¹ However, their cognitive capacities were limited by the small size of their brains, which was comparable to those of chimpanzees. Known as the "handy man," *Homo habilis* is one of the earliest species in the *Homo* genus. *Homo habilis*'s ability to make and use basic tools, a crucial stage in intellectual evolution, was made possible by its larger brain than *Australopithecus*. Using tools demonstrates a greater capacity for planning, problem-solving, and environmental adaptation early indicators of the intellectual path that would eventually give rise to modern humans.²

After evolving in Africa, *Homo sapiens* rose to prominence as the leading hominid species. The brains of *Homo sapiens*, which had an average size of 1,300 to 1,400 cubic centimeters, were able to perform higher-order cognitive tasks like planning, problem-solving, and abstract reasoning. The first *Homo sapiens* created increasingly complicated tools, created art, and displayed sophisticated social behaviors. Because they enabled people to learn language, collaborate in bigger groups, and adapt to a variety of situations, these cognitive developments were critical to human survival.³

The Cognitive Revolution, during which *Homo sapiens* started to display traits and abilities that distinguished them from other animals, was a pivotal period in human evolution. This

¹ Ian Tattersall, *Understanding Human Evolution*, Cambridge University Press, Online publication, July 2022
<https://doi.org/10.1017/9781009106177>

² *ibid*

³ Yuval Noah Harari, *Sapiens: A Brief History of Humankind*

involved the creation of intricate social structures and stories, the development of language, and the capacity for symbolic thought. This innovation made it possible for people to share information across generations and work together in big, adaptable groups. Because of this, humans were able to outcompete other hominin species and take control of the planet.” “A significant turning point in the intellectual development of humans was the Scientific Revolution (16th–18th century). Our knowledge of the cosmos and the laws of nature was drastically altered by individuals such as Copernicus, Galileo, Newton, and others. The foundation for contemporary science, technology, and logical thought was established during this time, which resulted in the technical breakthroughs that characterize contemporary civilization.⁴

The Industrial Revolution (18th–19th centuries): This period of time changed economies, civilizations, and human behavior by utilizing science and technology. Innovations in communication, transportation, and machinery sped up economic growth and intellectual advancement.⁵

The Information Age (20th–21st century): The introduction of computers, the internet, and artificial intelligence (AI) during this time period elevated human cognition to previously unheard-of heights. Human society has been completely transformed by the capacity to store, distribute, and evaluate enormous volumes of data. By enabling humans to investigate the nature of intelligence, advances in genetics, neurology, and artificial intelligence are opening up new possibilities for cognitive evolution in the future. In addition to biological evolution, human intellect has undergone cultural change. Technology. Humans have been able to build on the intellectual accomplishments of earlier generations through education, socialization, and the transmission of information across generations, resulting in a cumulative process of cultural development. The Future of Human Intellectual progress Both biological and technological developments may influence intellectual progress in the future. The rapid advancement of space technology has revolutionized global communication, navigation, defense, and scientific exploration. However, these developments have also led to the unintended consequence of space pollution, which poses significant environmental challenges.⁶

⁴ Robin Briggs, (March 1970) , Scientific Revolution of the 17th Century (Seminar Studies in History)

⁵ Peter N Stearns, (August 2012The Industrial Revolution in World History,)

⁶ Manuel Castells, (October 2009)The Rise of the Network Society: The Information Age: Economy, Society, and Culture Volume I: 01 (Information Age Series)

Definition of Space Law:⁷

The body of legislation that governs space operation, like the exploration, utilization, and preservation of space resources, celestial bodies, and outer space, is known as space law. International law covers up nearly every aspect of space law. International treaties, agreements, and national laws are becoming more and more crucial for controlling space activities as space exploration and research expand.

The Role of International Law in Addressing Space Pollution

The Outer Space Treaty (1967):⁸ The most basic legal foundation for space operations is the Outer Space Treaty (1967). It guarantees that outer space is open for exploration and usage by all nations and establishes space exploration as a worldwide endeavor for the good of all people. It guarantees peaceful space exploration and forbids the stationing of nuclear weapons in orbit. Additionally, it forbids any nation from claiming ownership of the Moon or other planets, among other celestial bodies.

The Rescue Agreement (1968):⁹ This treaty ensures that astronauts are to be rescued and returned safely in the event of an emergency in space. It emphasizes international cooperation.

The Liability Convention (1972):¹⁰ This outlines the liability of states for any damage caused by their space activities, both on Earth and in space, including damage from space debris.

The Registration Convention (1976):¹¹ States must register space objects launched into orbit or beyond with the United Nations, providing transparency about space activities.

The Moon Agreement (1979):¹² Expands on the Outer Space Treaty, asserting that the Moon and other celestial bodies are the common heritage of all humankind, and their resources should be used for the benefit of all, not for exclusive national ownership.

The Space Debris Mitigation Guidelines: The UN Office for Outer Space Affairs (UNOOSA) and space-faring countries have established guidelines for the mitigation of space debris,

⁷ The United Nations Office for Outer Space Affairs, <https://www.unoosa.org/oosa/en/ourwork/copuos/current.html>

⁸ <https://www.unoosa.org/oosa/en/ourwork/spacelaw/publications.html>

⁹ *ibid*

¹⁰ *ibid*

¹¹ *ibid*

¹² *ibid*

including preventing the creation of new debris and ensuring that space activities are conducted safely. These guidelines help reduce the risks posed by space debris, but they are not legally binding. However, they represent an effort to balance the growing demands of space exploration with the need to safeguard global security and the well-being of humanity.

Key Issues in Space Law:

Space Resource Utilization: With the rise of private space ventures, there are growing concerns over the mining of asteroids, the Moon, and other celestial bodies. The question arises about whether countries or companies can claim ownership or rights to space resources, and under what legal frameworks.

Space Resource Utilization treaties, such as the U.S. Commercial Space Launch Competitiveness Act (2015) and Artemis Accords (2020), have sparked debates on the private use of space resources.

Space Traffic Management: With increasing numbers of satellites, space debris, and private sector activity, ensuring safe and sustainable use of space is a growing concern. Space law deals with issues like collision avoidance, traffic management, and debris mitigation.

Military Use of Space: The Outer Space Treaty forbids military bases on celestial bodies but does not prohibit military activities in space. Nations are thus working on laws and agreements related to the militarization of space, such as satellite defense, anti-satellite weapons, and space security.

National Space Laws: Countries like the U.S. (with NASA and the Commercial Space Launch Competitiveness Act), Russia, China, and European Union members have their own space regulations to govern activities like satellite launches, space exploration, and private sector space operations. For example, SpaceX and Blue Origin operate under national laws in the U.S.

Environmental Regulations and Space:**Technological Development and Space Pollution: Impact on the Environment**

The rapid advancement of space technology has revolutionized global communication, navigation, defense, and scientific exploration. However, these developments have also led to

the unintended consequence of space pollution, which poses significant environmental challenges. The concept of space pollution refers to the growing issue of space debris and other human-caused environmental damage in outer space. As space exploration and satellite launches increase, space is becoming increasingly cluttered with non-functional objects, abandoned satellites, spent rocket stages, and fragments from collisions or accidents. While space pollution itself is not a direct violation of human rights, it can have serious implications for human rights and global governance. The consequences of space pollution may infringe on the rights of individuals and societies in various ways, leading to calls for stronger regulation and accountability. As space pollution increasingly becomes a global concern, there have been calls to create specific regulations that protect both space and Earth's environment. This includes ensuring that space missions follow strict guidelines to prevent space debris accumulation and ensure that objects do not re-enter Earth's atmosphere in ways that could cause damage to human life or the environment. In recent years, countries and private companies have explored the possibility of space debris removal technologies that could reduce the amount of debris in orbit, thus safeguarding satellites and potentially reducing risks to human safety. As space exploration continues to expand, questions about the ethical use of space are becoming increasingly relevant. The push for creating a global governance structure around space exploration and pollution is gaining traction, and this structure would ensure that space activities do not harm people's rights to privacy, safety, or a healthy environment. The right to access space is also a topic of debate, as only a few nations and private entities currently have the technology to access space, which could create an imbalance in the benefits derived from space exploration and use.

Human Rights Implications in the Age of Mega-Constellations

Mega-constellations like SpaceX's Starlink have raised concerns regarding both space pollution and human rights. These mega-constellations involve launching thousands of satellites into orbit, and while they aim to provide global internet coverage, they also contribute to space debris. The concerns include:

Astronomical Research: Space mega-constellations are creating light pollution that interferes with astronomical observations. This can be seen as a violation of the right to scientific progress and discovery, as researchers are increasingly finding it difficult to observe the stars due to the high number of satellites in orbit.

Security Concerns: The proliferation of satellites could increase the risk of space

weaponization or the use of space-based technologies for mass surveillance, which can infringe on individuals' rights to privacy and freedom from surveillance. Space technology advancements have resulted in several forms of pollution, including:

Space Debris: Space debris refers to defunct satellites, spent rocket stages, and fragments from collisions in Earth's orbit. Increasing launches of satellites, especially mega-constellations, exacerbate debris generation. Breakups and collisions (e.g., the 2009 Iridium-Kosmos collision) also contribute significantly. Over 36,000 pieces of trackable debris and millions of smaller fragments orbit Earth, posing risks to operational satellites and space missions. Non-functional satellites, rocket parts, defunct spacecraft, and fragments from previous collisions (e.g., debris from the destruction of satellites or rockets).

Light Pollution: Bright artificial light from satellites, such as those in low-Earth orbit (LEO), can obscure astronomical observations. The growing number of reflective satellites in constellations like Starlink affects ground-based telescopes and reduces night-sky visibility.

Atmospheric Pollution: Rocket launches release pollutants into the atmosphere, including soot, aluminum oxide, and greenhouse gases. Solid rocket propellants and re-entry of spacecraft contribute to the release of harmful chemicals.

Orbital Congestion: Crowding in popular orbital altitudes increases the likelihood of collisions, leading to a cascading effect known as the Kessler Syndrome.

Impact on the Environment:

Earth's Atmosphere:

- **Ozone Depletion:** Rocket exhaust, especially chlorine-based compounds, damages the ozone layer, reducing its ability to shield Earth from harmful ultraviolet radiation.
- **Greenhouse Gas Emissions:** Launch activities contribute to carbon dioxide and water vapor release, exacerbating climate change.

Space Environment:

- **Threat to Operational Satellites:** Space debris impacts active satellites, disrupting essential services like communication, navigation, and weather forecasting.

- Kessler Syndrome: The cascading debris effect could render certain orbital regions unusable for decades.

Astronomical Observations:

- Impact on Research: Light pollution from satellite constellations interferes with ground-based telescopes, compromising astronomical studies and the detection of celestial phenomena.

Surface Pollution:

- Re-entry Debris: Uncontrolled re-entry of spacecraft can result in fragments reaching Earth's surface, posing risks to ecosystems and human settlements.

Human Rights Violations Associated with Space Pollution

Although space pollution itself doesn't directly violate human rights, its effects can indirectly threaten or infringe upon the rights of individuals and communities in the following ways:

1. Right to a Safe and Healthy Environment

- Space pollution, especially space debris, poses risks to space exploration and satellite communications that are vital for global communications, weather forecasting, and disaster management.
- Right to Access to Information: The increasing clutter in space may make it more difficult to maintain satellite functionality, especially for critical services. Disruptions in satellite communications or geospatial data services could affect many individuals and communities, depriving them of the information necessary to make informed decisions about their safety, health, and well-being.
- Health and Safety Concerns: There is the potential for accidents or collisions between debris and functional satellites. The destruction of satellites could disrupt important services like global internet access, navigation systems (GPS), and telecommunications, which are essential to human life. In some cases, the damage from space debris could also pose risks to human life in space missions, which could be seen as a violation of the right to life and security.

2. Right to Privacy

- **Satellite Surveillance:** The rapid growth of satellite constellations for various commercial purposes, including surveillance, could potentially infringe on people's right to privacy. For example, megaconstellations may lead to mass surveillance of individuals and communities across the world.
- **Space Junk as a Risk to Satellites:** Space debris may pose a danger to private and government-owned satellites, which could further infringe upon the right to privacy if those satellites are being used for data collection, communication, or surveillance purposes.

3. Impact on the Right to Development

- Space pollution may have broader economic implications for nations that rely on space technology for development. For instance, countries that depend on satellite communications for disaster management, environmental monitoring, or healthcare systems could be negatively impacted by space debris.
- The disruption of satellite systems, including weather forecasting satellites, could exacerbate vulnerabilities, particularly for developing nations that rely on satellite data to improve agriculture, monitor climate change, and safeguard their citizens.

4. Environmental Damage and Its Global Impact

- Though space itself is often considered a "commons," space pollution could lead to harmful consequences on Earth's environment. For example, debris from spacecraft or satellites that re-enter the Earth's atmosphere could cause fires or pose hazards to people, leading to potential harm and a violation of their rights to safety.
- Additionally, the space industry's emissions and the potential for space debris to re-enter Earth's atmosphere could contribute to climate change indirectly, impacting the right to a healthy environment for future generations.

Mitigation Strategies and Solutions

Sustainable Space Practices:

- Design satellites and rockets with end-of-life disposal plans, such as controlled de-orbiting.
- Develop reusable rockets to minimize waste and launch-related emissions.

Advanced Technology for Debris Removal:

Active Debris Removal (ADR): Use of robotic arms, nets, and harpoons to capture and remove debris.

Laser Systems: Ground-based lasers to alter the trajectory of debris, causing it to burn up in the atmosphere.

International Collaboration:

- Adherence to space debris mitigation guidelines by organizations like the UN Committee on the Peaceful Uses of Outer Space (COPUOS).
- Partnerships for global monitoring of space debris through programs like the Space Surveillance Network (SSN).

Regulations and Policies:

- Develop national and international regulations to limit the number of satellites in LEO and mandate compliance with debris mitigation practices.

Environmental Impact Assessments:

- Conduct assessments for new space missions to evaluate and mitigate their environmental impact.

Looking Ahead: Balancing Development and Sustainability

Technological advancements in space exploration and utilization have opened new horizons, but they also necessitate responsible stewardship of Earth's orbit and environment. Sustainable practices, innovative debris management technologies, and stringent regulations are essential to mitigate the adverse impacts of space pollution. Through proactive measures, the global

space community can ensure that technological progress does not compromise the environmental balance, preserving space as a resource for future generations.

Socio-Legal Concerns

1. **Space Debris Generation:** India's space program contributes to the growing issue of space debris, including remnants of rockets, defunct satellites, and fragments from collisions. The socio-legal concern arises from the potential liability under international law for damages caused by Indian space debris.
2. **Sustainability of Outer Space Activities:** The exponential growth of satellites launched by ISRO and private entities underlines the need for sustainable practices. Overcrowding in certain orbits could lead to collisions, worsening the debris problem and threatening India's assets in space.
3. **Compliance with International Laws:** India is a signatory to key international treaties such as the Outer Space Treaty (1967) and the Liability Convention (1972). Challenges arise in enforcing these treaties domestically and ensuring compliance with evolving norms like those from the UN Committee on the Peaceful Uses of Outer Space (COPUOS).
4. **“Private Sector Participation:** The rise of private companies in India's space sector under initiatives like IN-SPACe brings new challenges in monitoring and regulating their activities. Ensuring private entities adhere to space debris mitigation guidelines and legal frameworks is critical.
5. **Environmental and Ethical Issues:** Space pollution indirectly affects Earth's environment, as pollutants from rocket launches may contribute to atmospheric damage. Ethical concerns include the responsible use of shared space resources and prioritizing long-term sustainability over profit.

Challenges:

1. **Regulatory Framework:** India currently lacks comprehensive domestic legislation addressing space pollution and liability. The Draft Space Activities Bill, aimed at regulating space activities and addressing liability, has not been enacted.

2. **Technical Limitations:** Developing technologies for tracking, mitigating, and removing space debris requires significant investment. India's existing capabilities in space debris management, though growing, need to scale up rapidly.
3. **International Collaboration:** Space pollution is a global issue requiring collaborative efforts. India must actively participate in global initiatives like the Space Debris Mitigation Guidelines by COPUOS. Geopolitical tensions can hinder effective international cooperation on space governance.
4. **Awareness and Public Engagement:** Public understanding of space pollution's impact is limited in India. Building awareness can foster support for policies and sustainable practices.
5. **Balancing Development and Sustainability:** India's aspirations to expand its space sector, including mega-constellations of satellites, must align with sustainability goals. This involves balancing economic development with environmental and legal responsibilities.

Steps Forward

1. **Enact Comprehensive Legislation:** India must expedite the passage of the Space Activities Bill to establish a robust legal framework for addressing space pollution and private sector regulation.
2. **Strengthen International Collaboration:** India should advocate for global standards and actively contribute to international efforts in space debris mitigation and removal technologies.
3. **Promote Research and Innovation:** Investment in research for debris tracking, active removal systems, and sustainable launch technologies is essential.
4. **Public and Private Sector Synergy:** Collaboration between ISRO, private entities, and academic institutions can ensure adherence to legal norms while fostering innovation.
5. **Awareness Campaigns:** Engaging stakeholders and the public through education and outreach can build a culture of sustainability in India's space activities.

Conclusion:

Space pollution itself is not inherently a direct violation of human rights, but its consequences can potentially infringe upon several rights, such as the right to a safe environment, privacy, and access to information. As space activities continue to grow, it is crucial that international laws and regulations evolve to address both space pollution and its human rights implications. This requires a careful balance between fostering innovation in space exploration and ensuring that the benefits of space are accessible and safe for all people, without compromising their rights or the environment. Balancing space pollution with environmental sustainability is a complex challenge that requires a multidisciplinary approach involving technological innovation, international cooperation, and robust governance. Here are strategies to address this issue effectively. India's journey into space exploration has been marked by remarkable achievements, including satellite launches, interplanetary missions, and a growing presence in the global space economy. However, with increasing activity in space, India, like other spacefaring nations, faces socio-legal concerns and challenges related to space pollution.