The Effect of Space Launches on Climate: A Legal and Policy Perspective

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Energy production, transportation, and industrial operations, which have higher carbon footprints, are frequently the focus of climate change mitigation measures. It is important to keep in mind that the processes involved in outer space launch operations, such as manufacturing, shipping and infrastructure construction have environmental impacts as well. It is critical to take into account the possible effects of space launches on the Earth's climate from a legal and regulatory perspective as the space industry is expanded rapidly. When rocket propellants burn, carbon dioxide (CO2) and harmful gases are released into the atmosphere, which contributes to greenhouse gas emissions from space launches. This research paper in Part II elaborates on human rights perspective to climate change. Part III investigates the influence of outer space activities on climate. In Part IV, the evaluation of the disproportionate effects of space launch emissions on marginalised and vulnerable populations is discussed, with an emphasis on the concepts of climate justice and equity. Part V conducts a study of national laws, international environmental treaties, space law and policy procedures asserting liability and determining compensation for potential climate damage resulting from space launch activities. Part VI proposes establishment of specific liability frameworks and policy considerations through international cooperation for space launch operations liable for any negative climate repercussions along with incentivizing sustainable propulsion technologies and supporting green infrastructure.

Keywords: outer space, climate change, policy, sustainable space technology

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Introduction

Humanity has set out on an incredible voyage of exploration and discovery across the infinite outer space, going beyond the boundaries of our planet to solve the enigmas of the universe. Outer space launch operations are essential to this journey of discovery as it constitute large-scale projects that launch spacecraft into orbit, allowing human scientific research and technology advancement to reach new dimensions. The environmental effects of space launch operations,

however, are a serious issue that demands consideration in the midst of the breathtaking space exploration that involves rocket launches and space missions.

The relationship between environmental sustainability and space exploration is a fundamental paradox that combines the need to protect the fragile balance of our planet's ecosystems with the limitless possibilities for human growth. Although space launches represent enormous strides forward for humanity, they also have a noticeable negative impact on the environment. Bringing with them ecological fallout requires consideration and reflection on our part.

This study delves into the complex and confusing world of space launch operations, analysing the environmental implications and revealing the complex network of causal links that underlie the effects of space launches on the surrounding ecosystem. Each thread of this complex tapestry provides a glimpse into the ecological consequences, ranging from the pollution released during rocket launches to the destruction of terrestrial ecosystems and the growth of space junk in Earth's orbit.

Statement of problem

The number of space launches has increased dramatically in recent years due to both growing commercial interest and new developments in technology. Although these launches are essential for communication, scientific research, earth observation, remote sensing and national security, their effects on the environment likewise constitute a cause for concern. Among the most important environmental problems connected to space launches are the release of contaminants, harm to ecosystems and production of space debris. A thorough understanding of the environmental consequences, scope, reasons, and possible mitigation techniques is necessary to address them. Therefore, evaluating the effects of space launch operations on the environment and identifying practical mitigation strategies and policies are the main goals of this research.

Literature Review

- Tanja Masson-Zwaan and Roberto Cassar, the Peaceful Uses of Outer Space (2019)
  The chapter depicts space negotiations as a consequence of the USSR and US government working together at UNCOPUOS to guarantee the peaceful use and exploration of space, space law was created. The Outer Space Treaty discussions demonstrated how these two global giants put aside their political differences to come to a mutually beneficial legal agreement. The chapter questions the continued applicability of UNCOPUOS and international space law in offering a framework for the peaceful use and exploration of space.
- Michael Byers and Aaron Boley, Mega-constellations and International Law (2023)
  In the framework of international law, this chapter addresses the difficulties brought about by the rapid expansion of mega-constellations, with a focus on satellite collision and subsequent accountability. It draws attention to the fact how difficult it is to prove causality in knock-on collisions, in which spacecraft are struck by debris from an earlier collision. Determining what constitutes appropriate behaviour and negligence is difficult since there are no legally enforceable international standards for the construction and operation of satellites.
- Steve Mirmina and Caryn Schenewerk, International Space Law and Space Laws of the United States (2022)

The book highlights the significance of international collaboration by giving a brief history of space exploration and the evolution of space law throughout the first 50 years. The United States' domestic laws governing space-related operations are covered in great detail in the second part of the book. To meet its international duties under the Outer Space Treaties, the United States has established domestic laws and regulations to incorporate its legally binding commitments into its domestic legal system. As required by Article VI of the Outer Space Treaty, these domestic rules and regulations pertaining to space-related activities are intended to authorize and supervise the actions of U.S. nationals in outer space.

- Alla Pozdnakova, Pollution of the Marine Environment by Spaceflights, (2023)
  The chapter (Book – The Environmental Rule of Law for Oceans) discusses the need for an effective environmental legal regime in the space sector and the use of general environmental laws and multilateral environmental agreements to address pollution caused by spaceflights. Due to the release of hazardous materials into the atmosphere and the discarding of space launch vehicle and deorbiting spacecraft components, spaceflights have the potential to pollute the Earth's ecology, especially its marine environment. This pollution source has not received much worldwide attention, despite the fact that it could potentially be substantial. The applicable environmental law provisions are drawn from general environmental laws and multilateral environmental accords like the UN Convention on the Law of the Sea in the lack of particular environmental provisions in the international law of outer space. The author states that prior to establishing any significant regulations, primarily focus should be on building the international institutional framework and acquiring scientific data regarding the effects of spaceflights on the maritime environment.
- H. A. Simpson, Regulating Science Fiction: The Regulatory Deficiencies in a Rapidly Growing Commercial Space Industry (2015)

The paper addresses how the emergence of satellite mega-constellations has led to inadequacies in the legal system controlling commercial space. It outlines the pertinent legal framework and the urgent issues surrounding space exploration. It also notes that the industry is mostly in charge of regulating satellite constellations. It does not, however, get into specifics about the legal ramifications of satellite constellations.

Along with other literatures analysed, the gap identified is related to discussion with respect to different stages and phases of space launches. Whenever, a space object is launched beyond the Earth it involves manufacturing, launching, orbiting and final disposal. These stages have diverse implications, including on climate, which are still not addresses and governed.

Research Objective

1. To examine the impacts on the environmental implications of outer space operations.
2. To evaluate the scope and scale of environmental effects related to various space launch operations phases, such as rocket construction, fuelling, launch and spacecraft dismantlement.
3. To assess current practices and mitigation strategies, along with regulatory compliance for reducing the environmental impact of space launches.
4. To suggest recommendations for minimising environmental footprint of outer space operations and ensure space sustainability.

Research Methodology

This study adopt doctrinal method of research focuses on secondary data including legal texts, international instruments, statutes, regulations, and academic literature to analyse legal ideas, theories, and frameworks, in contrast to empirical research, which is dependent on primary data gathering and analysis.

Human Rights Perspective to Climate Change

Climate factors, such as humidity, temperature, rainfall, wind patterns and the changing seasons, have a significant impact on ecological interactions and processes as well as the distribution, prosperity and conduct of plant and animal species. Variations in the climate can cause disturbances to these relationships, resulting in changes to the ecosystems, diversity of species and fluctuations in population dynamics (Robinson, 2009). Climate change constitutes a human rights crisis as well rather than just an environmental problem.

Many human rights are violated by the negative consequences of climate change, including the rights to food, water, shelter, health, life and self-determination (Posner & Sunstein, 2007). These rights are seriously threatened by climate change, which can result in severe weather, disrupted monsoon patterns, elevated sea levels, food and water insecurity. The fundamental base to the human rights perspective on climate change is the recognition of the right to a healthy environment (Mboya, 2020). The acknowledgement of the right to a healthy environment is fundamental to the human rights viewpoint on climate change. With the devastating ecosystems, contaminating the air and water making ecological hazards more prevalent, climate change threatens this right. Consequently, preserving and improving the environment is crucial to ensuring the health and welfare of people. Achieving the Sustainable Development Goals (SDGs) is hampered by climate change, which presents serious obstacles to sustainable development (Nguyen & Nguyen, 2022). Extreme weather and natural disasters are two effects of climate change that can thwart development efforts, worsen poverty, and widen economic disparities. Climate-related relocating and loss of livelihoods violate people's rights to dignity and self-determination.

Although the effects of climate change are seen globally, it disproportionately harms the vulnerable populations, aggravating already-existing disparities and jeopardizing the exercise of basic human rights. Those that are already at a higher risk of adaptation – such as women, children, individuals with impairments, and indigenous peoples – are disproportionately impacted. It is crucial that pressing issue of climate change is approached from a human rights perspective, giving equal emphasis to the defence and advancement of human rights.

Climate change is not just a consequence of individual or isolated actions but is deeply intertwined with systemic issues and structural inequities, including financial inequality, social injustice and political inactivity. While approaching climate change from a human rights perspective means acknowledging and redressing the structural inequities that underlie it (Limon, 2009). This involves somehow admitting that wealthy countries and companies have historically and currently contributed to climate change, disproportionately burdening developing nations and underprivileged groups. The nations lagging behind in technical revolution are burdened with the aftermath of growing economies. Drawing an analogy with the outer space sector, the space-faring nations are ahead in the race to frontier beyond the planet Earth. The expansion of space technology and satellite utilization is ahead in these nations compared to many other nations worldwide. Outer space despite being a common heritage of mankind (Nnadozie & Sule,

2022), is accessible only to few nations (now, commercial entities as well). The application of outer space industry is growing in modern affairs of human existence, such as navigation, remote sensing, and earth observation. Space-faring nations have initiated operations and somehow polluted outer space with orbital trash and debris, which might disrupt further exploration in the future and also have the potential to drastically affect the climate on Earth. The environmental implications of outer space activities are discussed in the following section.

Environmental Implications of Outer Space Operations

For many years, the fascination of space travel has captured the interest of individuals, encouraging governments, businesses and private organizations to explore the frontier beyond Earth in pursuit of possibilities, resources and information. The spectrum and dimension of space operations have increased substantially in recent decades, changing the cosmic landscape and the balance of environmental equilibria, ranging from satellite deployments and space tourism to interplanetary projects and space junk multiplication. The phases in outer space missions-commencing from the manufacturing of the parts of the satellite, launch, during operational life and disposal stage have implications that are visible.

Large amounts of energy, resources from the Earth, and materials such as metals, composites, electronics, and propellants are needed in the production of space assets. Significant quantities of energy and non-renewable resources are used in the extraction, processing and shipping of space asset production and operations. This can result in the loss of ecological diversity and environmental damage, especially in regions with extensive mining and manufacturing activity.

The release of contaminants during rocket launches constitutes significantly prominent impact on the Earth due to space launch operations. Liquid oxygen and hydrogen are examples of propellant fuels that rocket engines burn to produce the thrust required to launch spacecraft into orbit. When these fuels burn, a number of pollutants are released into the atmosphere, such as particulate matter, water vapor, carbon dioxide (CO2), and nitrogen oxides (NOx) (Ryan et al., 2022). These emissions have a negative impact on the atmospheric composition and climate, and also having the potential to undermine the progress made by Montreal Protocol with respect to ozone depletion (Ryan et al., 2022).

Space activities have a direct impact on terrestrial ecosystems and wildlife habitats, especially in the proximity of the space launch locations, in addition to orbiting trash and rocket propellant emissions. Outer space station establishment and missions have the potential to damage nearby ecosystems, impede the migration of species, intensify the dispersion and depletion of habitat. The space tourism sector is expanding at a rapid rate, which poses the question of whether it is sustainable to launch several commercial satellites into orbit given the energy, resources and emissions involved in each mission.

The rise of space debris forms a blanket of retired satellites, discarded rocket stages, and spacecraft components that orbit Earth at speeds surpassing thousands of kilometers per hour is one of the most critical environmental issues resulting from space operations (Akers, 2011). This expanding debris field threatens to cause catastrophic collisions and cascading effects (Kessler syndrome) (Kessler & Cour-Palais, 1978) posing a serious risk to functioning satellites, spacecraft and possibly the International Space Station. The accumulation of space junk is nevertheless a recurring and growing environmental problem, even with worldwide attempts to manage it (Chen, 2011). Satellite dumping into the ocean may release toxins and dangerous elements that endanger marine life, ecological systems and the quality of water. Batteries, propellants, and

electrical systems are not only a few of the parts that make up a satellite; some of these parts can contain dangerous or poisonous materials that could leak into the ocean upon landing.

The purposeful or inadvertent return of defunct or deactivated satellites into Earth are dumped into high seas at the end of their operational life (von Rebay, 2022). The potential hazards involved with the dumping of space debris in marine ecosystems give rise to issues over the ecology, safety and regulations surrounding the practice (von Rebay, 2022). Satellite elements that don't biodegrade easily, such metal pieces, thermal insulation, and composite materials, can linger in marine environments for long periods of time. This can affect marine ecosystems and habitats and expose marine creatures to the risk of becoming engulfed.

In order to establish liability and accountability for a nation, international law, in general, mandates that the negative consequence must be a result of action or omission of the nation, provided it has jurisdiction or control over it. While this standard of proof might be easily demonstrated in the case of transboundary river pollution due to space operations, however, it is far more challenging to prove in the case of global greenhouse gas emissions, where the consequences are the result of numerous State and non-State actors acting cumulatively across numerous jurisdictions (Lewis, 2018).

When it comes to the development and use of space assets, especially constellations of satellites and ground-based space infrastructure, light pollution is also a major environmental problem (Yakushina, 2023). Light pollution is the exorbitant or misdirected artificial light caused by human activity that interferes with the natural light patterns and has an adverse effect on ecological systems and astronomical observations (Koller et al., 2020).

Despite the common misconception that space is a serene and undisturbed place, human activity and presence there might have unavoidable environmental effects that compromise the sustainability and integrity of celestial bodies (Schafer, 1988). During landing or surface operations which includes robotic devices, landers and humans – may unintentionally spread microbial organisms, compounds and terrestrial organisms to the surfaces of celestial bodies. This contamination, referred to as "forward contamination," which might pollute samples, obstruct astrobiological study, and make it more difficult to discover things and jeopardize the scientific integrity of extraterrestrial settings. The expansion of operations considering space mining raises concerns. Mining activities have the potential to disrupt celestial bodies' natural regolith, surface materials and geological formations. Outer space is indefinite and still unexplored by human beings, and the nature and reaction of activities are unpredictable, with few or no precedents. The phases of space missions, including the disposal of satellites have huge implications on systems existing on and beyond Earth.

Disproportionate Impact of Outer Space Operations

Space tourism, mining of resources, navigation, communication via satellite, Earth observation, and scientific research are just a few of the many operations that constitute the space sector. Despite outer space being common heritage of mankind, it is clear that there is an unequal distribution of resources and advantages among the various actors participating in space exploration, exploitation, and usage (Venkatesan et al., 2020). This phenomenon is a reflection of variations in the space industry's investment, involvement, and impact, which are frequently influenced by technological, geopolitical, and economic reasons. Geopolitical factors have an impact on the space sector; major spacefaring nations, like the United States, Russia, China, and the European Union, have a considerable effect on space policies, laws, and operations.

These nations frequently give national security concerns, scientific development, and strategic goals prominence in their space programs, which results in disparities in transfer of technology, accessibility to space resources, environmental concerns and global partnerships.

The space industry is substantially shaped with advancements in technology, which in turn encourage innovation in satellite systems, orbital infrastructure and the exploration of space (Vicas, 1980). However, proficient spacefaring countries and commercial space enterprises tend to have exclusive access to cutting-edge technology and professional expertise, which creates gaps in technological capability and competitiveness among various industry players. Smaller nations and beginners in the space industry may find it challenging to keep up with the swift improvements in technology and may encounter problems in obtaining and utilizing space technology to achieve economic and social growth. Additionally, this can lead to obstacles for entry and inadequate chances for significant participation in the global space economy for emerging space powers and underdeveloped nations.

The environmental cost of human operations outside Earth's atmosphere is still largely hidden and underestimated, while the glories of space entice us with prospects of discovery and advancement. In reality, the unexpected repercussions of our cosmic goals are brought to light by the disproportionate impacts of space operations. Globally, space faring nations somewhat achieved advance facilities of navigation, communication, remote sensing, among others. The impact of space operations is global; however, the benefits are limited to a few privileged.

The space industry's resource allocation is impacted by conflicting priorities, market demand and regulatory aspirations. Different segments of the space industry (communication, navigation, earth observation, research etc.) confront variations in resource allocation due to competing interests for capital funding, commitments, agreements and research opportunities provided by government space agencies, private space corporations, academic institutions, and international organizations (McDougal & Lipson, 1958) Furthermore, the allocation of resources and investment decisions for space projects are often influenced by political agendas, budgetary restrictions, commercial interests, international relations and changing policy objectives. This might exacerbate the differences in financing and support for space endeavours. Nations ailing for basic human rights such as water, food and shelter will not make budgetary commitments for space industry to flourish. Nevertheless, these nations are not aloof from the impact of excessive outer space activities.

Numerous advantages are provided by the space industry, such as novel scientific findings, technology developments, business prospects and collective benefits (Reinstein, 1999). However, various stakeholders often enjoy unequal access to these advantages. Certain industries, regions and communities benefit more than others. Developed nations with advanced space capabilities have the potential to derive higher economic rewards from commercial space endeavours, but poor nations are likely to experience difficulties in harnessing space technology for long-term growth (Wihlborg & Wijkman, 1981).

The excessive and ungoverned space operations by few concentrated stakeholders to fulfil their interests will jeopardize the interests of non-space faring nations and future generations. The mitigation strategies at this point can only curb the further deterioration of the space environment, but the space junk already created is a sign of future hinderance and compromise of inter-generational equity. In order to insure equitable access and utilization pf space resources, opportunities for all stakeholders collectively benefiting mankind should be a priority (Kostenko, 2023).

Climate change and Outer space: Legal and Policy Analysis

Integrating perspectives regarding impact evaluation, environmental sustainability and holistic thinking provide an insightful examination of the space industry, shedding light on its intricate relationships with the environment and orienting efforts toward environmentally sustainable endeavours in outer space.

International environmental jurisprudence comprises a broad spectrum of legal doctrines, agreements and court rulings intended to resolve environmental concerns on a global level. Over the past few decades, this area of law has seen tremendous transformation in in response to mounting environmental issues such as pollution, ecological disbalance, global warming and climate change. Customary law, international treaties and soft law instruments regulate the legal and policy regime concerning environment. To address particular environmental challenges, nations negotiated multilateral environmental accords. These treaties address a wide variety of issues, such as maritime pollution ('International Convention for the Prevention of Pollution from Ships'), biodiversity protection ('Convention on Biological Diversity'), and climate change (Schipper, 2006) ('The United Nations Framework Convention on Climate Change'). These treaties give participating nations legally commitments and offer a framework for coordination and collaboration in dealing with environmental concerns. However, these lack imposing any kind of obligation specifically to outer space activities.

The Convention on Climate Change (UNFCCC) and the subsequent protocols, namely the Kyoto Protocol (Kyoto Protocol, 1998) and the Paris Agreement, create broad guidelines for international climate action, defining goals for reducing emissions, encouraging collaboration among nations and streamlining procedures for providing funding and transferring technology to developing nations (Kuyper et al., 2018). The UNFCCC can be considered to have implications for space operations owing to potential environmental effects of space activities on Earth's climate system, even though its primary focus is on terrestrial sources of greenhouse gas emissions and related climate measures. Countries with active space programs may help mitigate climate change and promote sustainable space resource use in line with UNFCCC commitments by incorporating climate change concerns into space policy and planning. Apart from comprehensive treaties, environment protection is dealt specifically with respect to outer space operations in international instruments. The provisions seek to guarantee that space operations are carried out in a way that avoids damage to the environment and encourages the sustainable use of resources in space.

The fundamental agreement that regulates operations in space is the Outer Space Treaty, 1967. Article IX of the treaty requires nations carrying out operations in space to prevent detrimental pollution of ecosystems and celestial bodies (Taubenfeld, 1973). A broad idea of protecting the environment in space is reflected in this clause. The notion of absolute culpability for harm caused by space objects, irrespective of fault, is established by the Liability Convention, 1972 (Dennerley, 2018). Liability for environmental harm resulting from space objects, including satellite collisions or the re-entry of space trash, is included. The treaty places a strong emphasis on protecting the environment and making space-faring countries responsible for any harm on 'Earth's surface or aircraft in flight' due to their space operations (Art. II).

States are required under the Registration Convention, 1975 to register space objects that are launched and submit details regarding their orbital characteristics (von der Dunk, 2003). The treaty's main goal is to streamline space object monitoring and recognition easier, but it also indirectly aids environmental conservation by encouraging responsibility, accountability

and transparency in space operations. The Moon Agreement, 1979 encompasses measures to safeguard the environment as well as the usage and exploitation of lunar resources (Bini, 2008). The agreement in Art. VII emphasizes the significance of environmental preservation in space exploration on and beyond Earth while establishing guidelines for the sustainable development of the Moon and other celestial bodies.

International law encompasses not only legally binding treaties but also non-binding guidelines, declarations and principles that set standards and norms for nations and other relevant parties. Soft law instruments are complimentary in determining global governance and encouraging international collaboration. International efforts have been undertaken specifically to create standards and mitigating techniques to address the problem of space debris. To reduce the chance of accidents with debris, space agencies and satellite operators, for instance, use collision prevention techniques. In order to minimize the production of debris, programs like the Space Debris Mitigation Guidelines 2007 (Inter-Agency, 2002) published by the United Nations Office for Outer Space Affairs (UNOOSA) offer guidelines for spacecraft design, operation, and end-of-life disposal. The spread of space debris, however, continues to be a chronic and growing environmental problem that calls for constant attention and cooperative action from the international space community. Member states and respective entities ought to voluntarily take measures to guarantee that guidelines are followed through methods and debris mitigation techniques, using their own appropriate means. There are no legally enforceable regulations requiring any entity to adhere to debris minimization criteria (Rajapaksa & Wijerathna, 2017). Due to the multiplicity of varying standards by different organizations and member states based on UN treaty rules and principles, it has led to ambiguity in the space exploration community concerning debris mitigation (Rajapaksa & Wijerathna, 2017).

Since the precautionary principle has garnered sufficient international acceptance, at least since the 1990s, to be considered as legal principle or, more importantly, a customary norm of international law (Mcinerney-Lankford et al., 2011), it would appear logical to recognize its applicability to the current space debris crisis. Hence, it is asserted that, insofar as the legal obligation to reduce the creation of space debris is concerned, Outer Space Law is complete. While applying with the precautionary principle, Launching States are required to take economical steps to control the increasing amount of space debris produced in order to safeguard the environment beyond Earth (de O. Bittencourt Neto, 2013).

The idea that states have a shared obligation to protect and restore the environment is encapsulated in the common but differentiated responsibilities and respective capacities (CBDRC) principle (Brunnée & Streck, 2013). The scope and magnitude of each state's individual responsibility may vary depending on their unique national circumstances (Brunnée & Streck, 2013). This idea has influenced way the climate regime has developed and has been crucial in encouraging cooperation and compromise. Similarly, this can be extended to outer space industry and it will be relevant for years to come.

Conclusions

A thorough and perceptive analysis of the space business is provided by integrating viewpoints from impact assessment, sustainable development, and holistic perspectives. The intricate relationships that the space industry has with the environment, society and economy must be highlighted in governance. Together, all of these perspectives help to better comprehend the environmental possibilities and problems related to space operations. It will also help in

formulating the sustainable future directions for the space sector. The space industry is massive and requires governance to keep both public and private sectors in a positive line of action, considering the interests of all mankind.

A critical assessment needs to emphasize on how urgent it is to implement comprehensive strategies that prioritize fairness, justice, and meaningful engagement in order to successfully combat climate change and protect 'everyone's right to human rights.' In 2010, during the IAM's 30th session in Geneva, Switzerland, leaders from the participating organizations decided to release a special report detailing ways UN agencies employ space-based technology to combat climate change. The report provides an overview of several operations, such as data collecting and distribution, standard creation, research and output generation, in addition to Earth observations for mitigating climate disturbances. Space technology when used in appropriate manner can be effective instrument to fight climate change instead of being a contribute to negative environment implications. The sustainable use of space resources and the mitigation of climate change may both be aided among nations by the sharing of space technology and experience as well as cooperative efforts to create cleaner propulsion systems and reduce space trash.

In contrast to conventional rocket engines, nations must develop biofuels, reusable launch vehicles and electric propulsion systems that emit less emissions and contaminants. The environmental impact of space launches may also be reduced by taking steps like launching rockets from isolated or unpopulated places and putting emission reduction technology into practice.

The precautionary principle, the concept of common but differentiated responsibilities, and the principle of intergenerational equity are examples of international environmental law principles that serve as fundamental guidelines for interpreting and carrying out international climate change provisions. These guidelines place a strong emphasis on the necessity of considering preventative action in the face of scientific uncertainty, acknowledging past emissions differences between countries, and taking future generations into account when making climate-related decisions.

Numerous nations have implemented legislative and regulatory measures in their jurisdiction to tackle the issue of climate change. These regulations should establish goals for reducing emissions, encourage the growth of renewable energy sources, impose carbon pricing schemes and create guidelines for energy efficiency and greenhouse gas emissions from the space sector. Sustainable space practices aim to reduce the consumption of resources, minimize the environmental impact of space operations, and mitigate waste formation and pollution. The space industry could accelerate space exploration and technological progress while addressing worldwide efforts to resolve climate change, declining biodiversity, and other ecological issues by adopting sustainability norms. With paradigm shift in outer space industry from closed government-oriented operations to commercialisation, makes it need of an hour.

When assessing the possible effects that space missions, satellite launches and the development of space infrastructure may have on the environment and society, environmental impact assessments (EIAs) and social impact assessments (SIAs) are crucial instruments. The assessment of impact aids in identifying possible hazards, deficiencies and trade-offs related to space operations, such as pollution, habitat damage, uprooting indigenous groups, and socioeconomic disparities. Stakeholders may minimize the negative effects of space industry operations while maximizing the good effects by carrying out thorough impact studies that help drive choices and mitigation strategies. It is recommended that SIAs or EIAs, be carried out in order to examine the possible environmental consequences of planned space launch operations

and determine the most effective way to minimize any negative effects. Furthermore, measures like conservation and habitat restoration should be designed in order to lessen the negative effects that space station have on nearby ecosystems and wildlife habitats.

Establishment of specific liability frameworks and policy deliberations through international cooperation complimenting the current regime will be considerate step towards streaming procedures in the space industry. Also, nations should set up mechanism for commercial entities defining their liability for any negative climate repercussions due to their operation. Also, commercial space entities should be encouraged by providing them funds and incentives to develop sustainable propulsion technologies and supporting green infrastructure.

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