STEERING SUSTAINABLE ENERGY INTO THE OUTER SPACE

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ABSTRACT

With the rapid expansion and growth in space technologies, the ability of a man to reach up above the world so high is quite elementary in nature. However, the process of landing, exploring and creating a new hospitable world outside, is causing damage to the hospitability of the existing world. In an attempt by the mankind to expand their habitats over and above, below and beyond, such as by the means of space tourism and space territory ownership, lot of geological as well as meteorological changes occur which in turn exerts a negative influence on the natural elements present. This article scouts over the nexus between the activities that are happening in the space and its consequent results such as emissions, scattering of debris, creation of aerosols and absorption of sunlight among others through secondary data and analysis of various literature by eminent scholars.

Keywords: space technology; space pollution; space tourism; emissions; outer space.

1. INTRODUCTION

It is undeniable that only with the help of extensive manoeuvring we can garner so much knowledge about space. The first step of getting to know the unknown is to step out in the dark and explore the same followed by the second step to assess the pros and cons out there and then slowly yet steadily harness the benefits from it by carefully avoiding its negative effects. Finally, when reaping benefits hit saturation, it is time to turn the exploitation tab back to the exploration tab by turning it a notch down. With regard to space exploration, we have attained the third step wherein now our efforts have to concentrate on how to milk the benefits from outer space and at the same time, ensure that the space is being protected and is not exploited.

Considering the aspect of everything comes with a cost, in this rat race of who is the first, countries tend to focus only on the short-term goal rather than forget the long-term goal of sustainability which in true form brings climate justice.

It is high time, that we think along the lines of sustainability not just considering Earth, but also outer space which is by far the most sought by the nation-states for all possible motives and desires.

2. METHODOLOGY

The study is largely substantiated through secondary data which includes various articles, books, journals and reports from reputed and genuine domestic as well as international organisations and reporters. This paper will employ exploratory and analytical methodologies for research.

3. LITERATURE REVIEW

In 'Space Sustainability and Debris Mitigation' authored by Johnson, he gives an account of how space debris mitigation can steer sustainability in space. To highlight this point, he states how international bodies are working on this concern with the help of various guidelines and policies and provides that approval has been received for 21 voluntary guidelines by 92 COPOUS members in 2019. However, the accountability aspect has been neglected whereby

there is complete uncertainty around who is responsible for cleaning up the existing debris[1].

Adding up to the above-mentioned article, Peter Martinez's work provides for the development and key features of the UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities, which will promote responsible and sustainable space activities. Nevertheless, the same is not legally binding under international law. It gives the option to the states to incorporate the same into their national legislation as well. The biggest limitation of this study is that considering the broad scope and flexibility offered, it might be difficult to implement the guidelines across different countries[2].

In 'The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space', author Rada Popova, enumerates how debris mitigation can singularly help in sustainability. The key point to be noted is that the main legal framework for space activities does not directly address space debris remediation, but there is a basis for protecting the outer space environment that could be used to develop voluntary, non-binding instruments for space debris remediation. The challenge posed here is the unclear criteria for defining and prioritizing the space debris that has to be eradicated[3].

In yet another paper on sustainability in space, the long-term aspect of sustainability has been discussed. It suggests that making the voluntary Long-Term Sustainability (LTS) Guidelines more binding, potentially through establishing them as customary international law, could help incentivize compliance and promote the long-term sustainability of outer space access and use. This would be an ideal scenario as states which did not sign up for this will also be brought under the umbrella of supervision[4].

In the article authored by Darrell Martin Lawson, he highlights the urgent need for sustainable space governance and active debris removal measures to avoid a critical "Kessler Event" in the coming years. The paper develops a forecasting model to estimate the imminent and costly debris crisis that will occur without the implementation of sustainable space governance. The

[1] Johnson, Space Sustainability and Debris Mitigation, KEY GOVERNANCE ISSUES IN SPACE, Sep. 1, 2020, pp. 5-17.
[2] Peter Martinez, The UN COPUOS Guidelines for the Long-term Sustainability of Outer Space Activities, 8 JOURNAL OF SAFETY ENGINEERING, Mar. 2021, pp. 98-107.
[3] Rada Popova, The Legal Framework for Space Debris Remediation as a Tool for Sustainability in Outer Space, MDPI, May 9, 2018.
[4] Larry F. Martinez, Legal Regime Sustainability In Outer Space: Theory And Practice, CAMBRIDGE UNIVERSITY PRESS, Dec 5, 2019.

major limitation is that the model only considers a single orbit, while different orbits have distinct critical densities that could lead to imbalances in the population distribution[5].

In the article titled 'Role of emerging nations in ensuring long-term space sustainability', the author provides an overview of the role of emerging space nations in ensuring the long-term sustainability of outer space activities through their increased participation in international fora, development of national space policies and legislation, and involvement in regional initiatives to promote information sharing and capacity building on space sustainability. However, there is a need for capacity-building initiatives to help emerging nations develop their technical and policy-making capabilities related to space sustainability[6].

4. RESEARCH AND REPORTS

Exploration of space is considered to be for the good of knowledge and the greater benefit for mankind living on Earth who is in the constant urge of knowing what is above and beyond. Upon thinking along these lines, there have been organisations that work for the cause, and try to gather the knowledge, in a sustainable manner.

In May 2024, NASA released its Space Sustainability Strategy which focuses on advancements NASA can make toward measuring and assessing space sustainability in Earth orbit, identifying cost-effective ways to meet sustainability targets, incentivizing the adoption of sustainable practices through technology and policy development, and increasing efforts to share and receive information with the rest of the global space community[7].

It has been divided into three different volumes of space sustainability documents. The first one is titled 'Earth Orbit'. Just as the title suggests, the report too primarily looks into sustainability in Earth's orbit, with plans for broader strategies in other domains in the future. The goals discussed in this report include - developing assessment frameworks, minimising uncertainties, enhancing technology, updating policies, improving collaboration, and strengthening internal organization. The second report is 'Cost and Benefit Analysis of Mitigating, Tracking, and Remediating Orbital Debris'. The report discusses the ability to

[5] Darrell Martin Lawson, A Holistic Systems Thinking Approach To Space Sustainability Via Space Debris Management, JOURNAL OF SPACE SAFETY ENGINEERING, 2023.
[6] M Rathnasabhapathy, Role Of Emerging Nations In Ensuring Long-Term Space Sustainability, 219 ACTA ASTRONAUTICA, June 2024, pp. 8-16.
[7] NASA's Space Sustainability Report - https://www.nasa.gov/spacesustainability/ .

detect the orbital debris in motion and then clean the same without causing further damage. The third report is titled 'Cost and Benefit Analysis of Orbital Debris Remediation' which analyses many remediation options for lowering the problems posed by orbital debris, such as moving, eliminating, or utilising it. According to the paper, some remediation options could generate more benefits than expenses in less than ten years[8].

The UNOOSA in the year 2021 released a set of guidelines that set forth 'The Long-Term Sustainability of Outer Space Activities of The Committee on The Peaceful Uses of Outer Space'. It has been divided into four parts which have been categorised as a background context for the guidelines, policy and regulatory framework for space activities, safety of space operations, international cooperation, capacity building and awareness and scientific and technical research and development[9].

5. OBJECTIVE OF THE STUDY

1. Space as such is something unknown, is it really worth it on our part to damage the present environment to learn something new? This will be the primary objective of the study

2. Apart from this we would look into Sustainable practices that are available instead of the conservative traditional practices. E.g. The use of liquid oxygen and liquid hydrogen instead of rocket fuel will only emit water vapour and significantly bring down any other forms of pollutants.

3. Thirdly we will be touching upon the norms and alternatives established by nation-states as there is a collective responsibility and only through a collaborative approach the space contamination be contained there needs to be uniform regulation that has to be followed by the world at large, and what happens upon its non-compliance.

6. RELATIONSHIP BETWEEN CLIMATE CHANGE AND SPACE SUSTAINABILITY

The UN has called climate change, 'the defining issue of our time and we are at the defining moment[10].'This climate change is not only happening because of our activities on Earth rather,

[8] *Ibid.*
[9] UNOOSA's Guidelines- https://www.unoosa.org/documents/pdf/PromotingSpaceSustainability/Publication_Final_English_June2021.pdf
[10] UN Report - https://www.un.org/en/global-issues/climate-change - :~:text=Climate Change is the defining,scope and unprecedented in scale.

it is the result of our holistic activities that are done below and above Earth. It also includes all those activities, that are performed in the name of advancement or development. Any kind of pollution or dissertation done inappropriately significantly affects the climate cycle of the Earth.

Launching of rockets

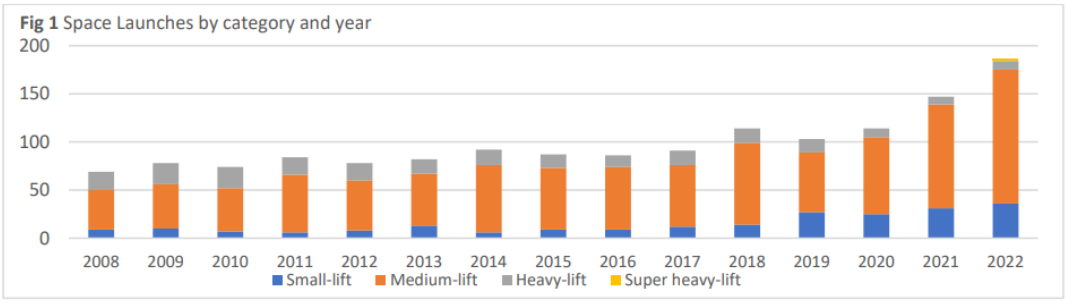

Figure 1

According to the Report of Executive Briefings on Trade, which happened in November 2023, the year 2022 had the maximum number of rocket launches[11].

It is a no-brainer that the increase in the number of rockets that are launched is commensurate to the technological advancement in the field of rocket science and space technology and the intervention of private players in the domain.

An interview that was recorded by PBS News in 2024, has stated that increasing the number of rocket launches by a factor of 10 could warm the stratosphere by as much as two degrees Celsius[12].

Another BBC source provides that discarded rockets may spill carcinogenic fuel which would be catastrophic and can poison a vast area[13].

[11] US Trade Commission's Report on Executive Briefings - https://www.usitc.gov/publications/332/executive_briefings/ebot_us_private_space_launch_industry_is_out_of_this_world.pdf.
[12] How a new space race could be harming the Earth's atmosphere, PBS NEWS (Nov. 1, 2024, 20:43PM) https://www.pbs.org/newshour/show/how-a-new-space-race-could-be-harming-the-earths-atmosphere .
[13] Richard Hollingham, When rockets go wrong – protecting the environment from catastrophe, BBC NEWS (Nov. 1, 2024, 20:47PM) https://www.bbc.com/future/article/20240627-the-environmental-cost-of-rocket-launches .

Apart from this many reports claim varied ill effects that could erupt because of the launch of rockets. Some of it includes – black carbon emissions, ozone degradation and reduced pH levels in the adjacent waters[14].

Alternative suggestions:

Thanks to scientific advancements, the best recourse against rocket pollution is the creation of sustainable rockets. These rockets are propelled by using liquid hydrogen instead of kerosene which negatively influences the air quality[15].

Apart from this photovoltaic energy can be used to reduce the air pollution that is caused due to a launch[16].

Orbex, an Aerospace company, uses bio-propane that is generated using waste residues and also adopts 3D printing to optimize the material usage of rockets[17].

Space Tourism

Space tourism is the newly emerged concept that gives the adrenaline rush to travellers who wish to have a peek at Earth far away from the land. It is the commercial use of space for space enthusiasts who wish to experience it for recreational purposes. It includes orbital, sub-orbital and even lunar tourism.

Space tourism affects the environment and outer space in all the ways that a rocket launch does. If at all to think in other lines, it only aggravates the existing effects, considering the number of people who wish to participate in this activity. The demand is capitalised by the private companies, which makes it easy to cross the Karmen Line.

[14] *Ibid.*
[15] Lily Carey, The Rocket Fuel of the Future May Be More Environmentally Friendly, DISCOVER (Nov. 1, 2024, 21:00PM) https://www.discovermagazine.com/environment/the-rocket-fuel-of-the-future-may-be-more-environmentally-friendly .
[16] Stephanie Safdie, Could a Rocket Launch Really Become 'Green' and Sustainable?, GREENLY (Nov.1, 2024, 21:04PM) https://greenly.earth/en-gb/blog/ecology-news/could-a-rocket-launch-really-become-green-and-sustainable .
[17] Aim for the stars: Making rocket launches more sustainable, AIRPORT TECHNOLOGY (Nov. 1, 2024, 21:09PM) https://www.airport-technology.com/sponsored/aim-for-the-stars-making-rocket-launches-more-sustainable/ .

The Blue Origin's Shepherd burns oxygen and hydrogen and hence, does not directly release harmful effluents. On the other hand, there is SpaceX's Falcon 9, which emits approximately 200 – 400 tons of carbon dioxide per launch[18].

Alternative suggestions:

All the countries should have a list of private agencies that can undertake launches and go about space tourism.

The private companies should be limited by the number of tours that can be taken by them beyond the Earth's surface.

The private companies should also be made aware of the effluent discharge level and if the same goes beyond a certain limit, they have to be severely penalised and banned as an extreme measure.

Satellite pollution

A satellite is a man-made object, that essentially revolves around another object, to furnish data or help in tracking and monitoring of resources. Considering the large-scale development, and the need to monitor and assess data, there lies in space many satellites which only adds up to the risk of collision and the resultant breakage and spread of debris along with noxious fumes.

As of December 2023, there were around 3,356 inactive satellites and in total around 12,597 spacecraft in orbit at that time[19].

When satellites re-enter the Earth's atmosphere, they tend to exert tiny particles of metals including sulphuric acid particles and chemicals which are quite harmful. Besides, the incineration of them expends aluminium oxide, which can cause instability in the thermal

[18] Frank de Veld, Space Tourism: A Closer Look on Safety Sustainability, SPACE GENERATION ADVISORY COUNCIL (Nov. 1, 2024, 22:22PM) https://spacegeneration.org/space-tourism-a-closer-look-on-safety-sustainability .

[19] Stacy Morris, State of Satellite Deployments & Orbital Operations – 2023 Report, SLINSHOT AEROSPACE (Nov. 1, 2024, 22:52PM) https://www.slingshot.space/news/state-of-satellite-deployments-and-orbital-operations-2023#:~:text=The%20report%20was%20compiled%20based,and%20sustainable%20use%20of%20space.%E2%80%9D&text=Among%20the%20key%20trends%20highlighted,all%20deployed%20spacecraft%20in%202023 .

temperature. Apart from this, they run on fossil fuels, which release soot and carbon dioxide[20].

Alternative suggestion

There has to be an international norm to which all the satellites have to conform concerning their bodies as well as their emissions. Any country that fails to adhere to the same, should not be allowed to launch their satellite.

Countries should propagate the use of Whipple shield technology. They are a special type of armour that can protect satellites from micro-meteoroids and orbital debris[21].

Entry of private players in the market

Given the greed for monetary as well as acumen wealth, man has traced his path into thin air forging his way into outer space all while adding up to the existing problems.

With more and more space vehicles, there is an increased risk of space debris which can even re-enter the Earth's surface. Given the magnitude of the satellites that are sent up, the mega constellations that are being formed cause significant light pollution which even has the potential to curb any future scientific development altogether[22].

Alternative suggestion

To keep a tab on their activities, it has to be mandated that all the private companies engaged in outer space exploration be appropriately licensed and authorised.

They should have a set of models and ideals that thrust upon themselves any liability that is supposed to arise because of their actions.

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[20] Tereza Putarova, Pollution from rocket launches and burning satellites could cause the next environmental emergency, SPACE.com (Nov. 1, 2024, 23:04PM) https://www.space.com/rocket-launches-satellite-reentries-air-pollution-concerns .

[21] 5 Ways to Shield Satellites from the Dangers of Space, NI SOLUTIONS (Nov.1, 2024, 23:11PM) https://www.ni.com/en/solutions/aerospace-defense/space-launch-exploration/satellite-design-test/5-ways-shield-satellites-dangers-space.html#:~:text=Whipple%20shields%2C%20named%20after%20their,and%20dispersing%20the%20incoming%20particle.

[22] Rajeev Suri, What's The Environmental Impact Of Space Debris And How Can We Solve It?, WORLD ECONOMIC FORUM, (Nov.2, 2024 01:19AM) https://www.weforum.org/stories/2022/07/environmental-impact-space-debris-how-to-solve-it/#:~:text=Mega-constellations%20in%20space%20pose,to%20dominate%20a%20particular%20orbit .

There should be a well-defined and strict compliance mechanism that has to be enforced by the respective nations and followed by the respective private parties.

It is to be noted that, all the satellites and all objects that are launched into outer space, do not come bearing only negative effects on the environment, rather, they also have a good side and help in the increase of knowledge and throw light on the unknown.

Rockets and satellites for starters, help climate research by providing data on deforestation, temperature change and ice distribution[23]. Apart from this, they help us to monitor the forest fires, by keeping track of the probable areas as it is the first symptom of climate change. Very soon, the carbon cycle of the Earth can also be understood as the scientists are creating new technology for the same[24].

Even though satellites and rockets are the ones when in multitudes, affect the ozone layer by depleting them, they are the ones that help them monitor too. Satellites help in identifying the holes in the ozone layer and go a step to measure the same. They tend to take pictures of the Earth and then help us to understand through visualisation the changing terrain and landscape[25].

It is a powerful tool when it comes to monitoring wildlife too. Without any human intervention that has the potential to disturb the daily lives of the animals, it helps to draw a wildlife habitat map consisting of the jaguar, elephants and tiger groups. This comes in handy especially while keeping a tab on endangered species[26]. It helps to identify any miscounts and at the same time prevent the happening of any illegal activity including poaching and unauthorised mining etc[27].

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[23] Anna Kunkel, A Walk In The Clouds: Green Propulsion For A Satellite-Based Technology, EVONIK (Nov. 2, 2024, 00:27AM) https://active-oxygens-sustainability.evonik.com/en/articles/green-propulsion-for-a-satellite-based-technology/#:~:text=It's%20not%20just%20about%20the,much%20easier%20and%20more%20efficient.

[24] How Space Science Can Help Us Combat Climate Change, UK RESEARCH AND INNOVATION (Nov. 2, 2024, 00:32AM) https://www.ukri.org/who-we-are/how-we-are-doing/research-outcomes-and-impact/stfc/how-space-science-can-help-us-combat-climate-change/#:~:text=Fighting%20forest%20fires,can%20help%20in%20several%20ways.

[25] Three Ways Satellites Help Us Understand Our Environment, NATIONAL AIR AND SPACE MUSEUM (Nov. 2, 2024 00:52AM) https://airandspace.si.edu/stories/editorial/three-ways-satellites-help-us-understand-our-environment .

[26] Transforming Nature Conservation With The Power Of Satellite Imagery, AIRBUS (Nov.2, 01:07AM) https://www.airbus.com/en/newsroom/stories/2023-04-transforming-nature-conservation-with-the-power-of-satellite-imagery#:~:text=Satellite%20imagery%20is%20changing%20conservation,that%20are%20harming%20our%20planet.

[27] Molly Hamm, The Power of Remote Sensing Satellite Images to Help Protect and Preserve Public Lands, PLANET LABS (Nov.2, 2024, 01:04AM) https://www.planet.com/pulse/remote-sensing-satellite-images/#:~:text=Governments%20use%20satellite%20imagery%20to,effectively%2C%20even%20with%20bu

7. LEGAL NORMS GOVERNING THE OUTER SPACE SUSTAINABILITY

The first Sustainable Space Economy workshop was conducted in 2019 in Finland and the satellite sustainability footprint and orbital capacity was discussed. The satellite sustainability footprint measures how likely the satellite stays healthy and operating, without causing risks to self or others and the orbit capacity is essentially an integral of the footprint over an orbit, and it determines how many satellites of different footprints could be launched to the same orbit.[28]

7.1 Space and Climate Change

The office of Outer Space Affairs has conducted workshops and symposium to promote awareness and capacity building activities by linking space and climate change as it is believed that the activities of human and the earth's climate are related and the human activities have an impact on the climate. Two concepts namely the space-based technologies and space derived information are used. Space technologies are necessary for understanding, monitoring, and predicting climate changes.[29]

The United Nations Intergovernmental panel on climate change has issued that by 2030 the global greenhouse gas emission should be reduced to half. The space mission that contributes to climate change research involve utilizing satellites to monitor various environmental phenomena, such as weather patterns, atmospheric conditions, and the state of oceans and sea ice. These satellites provide a wide-ranging view from space, making it possible to collect extensive data on a large scale. The UN General Assembly adopted "SPACE 2030" agenda to enhance the use of space activities for sustainable development. This initiative aims to advance space technologies for climate change observation and analysis, and to foster international collaboration in climate change mitigation. The UN's report also envisions space technologies playing a significant role in sustainable fisheries management, agriculture, and food safety. By implementing the Space2030 Agenda, member nations aim to ensure the long-term

dget%20constraints.&text=Governments%20also%20use%20satellite%20imagery,reefs%20in%20their%20ecological%20importance.&text=Satellite%20images%20help%20track%20animal,17%25%20of%20the%20world's%20wildlife.

[28] Palmroth, M., Tapio, J., Soucek, A., Perrels, A., Jah, M., Lönnqvist, M., ... & Virtanen, J. Towards sustainable use of space: Economic, Technological and Legal Perspectives Science Direct (May 11, 2021).

[29]Space and Climate Change (Nov.2, 23:22 PM) https://www.unoosa.org/oosa/en/ourwork/topics/space-and-climate-change.html

sustainability of outer space activities. [30]

The United Nations Committee on the Peaceful Use of Outer Space formed a working group on Long Term Sustainability of outer space activities in 2010 which was accepted in 2016 (12 of the proposed guidelines). In 2018, session of the UNCOPUOS was increased by a unispace 50+ which is about the UN's Sustainable Development Goals (SDG's). SpaceX in 2018 launched the Tesla automobile into a heliocentric orbit that crossed through the Martian orbital region some months later.[31]

The Prevention of an Arms Race in Outer space (PAROS) was adopted in the General Assembly in 1981. There are 2 adopted guidelines on which one is related to banning any type of space weapons including those that could target objectives on Earth and the other on ASATs. The Outer Space Treaty which came into force in 1967 also act as a form of arms control agreement. A draft proposal called the Prevention of the Placement of Weapons in Outer Space and of the Threat or Use of Force Against Outer Space Objects (PPWT) was introduced in the Conference on Disarmament (CD) in 2008. A draft International Code of Conduct for outer space activities was proposed by the European Union in 2008. The UN Member States have initiated two Group of Governmental Experts (GGE) processes to address PAROS through legal and non-legal means. A UN General Assembly guideline called the "Reducing space threats through norms, rules and principles of responsible behaviours" was adopted in 2020 by United Kingdom.[32]

7.2 The Principles Governing The Outer Space And Sustainability

Outer Space Treaty, 1967

Article I – The Outer Space Treaty grants the freedom to explore and use outer space, including the Moon and other celestial bodies. While this freedom promotes sustainability, it's not absolute. It's limited by the principle of equal rights for all nations and must be balanced with other treaty principles like cooperation and information sharing. However, the OST doesn't explicitly address space sustainability. While the freedom of exploration is significant, it cannot be restricted by individual nations, even those who are part of the OST. Ideas like taxing or

[30] An outer space perspective on climate change (Nov.3 00:30 AM) https://www.theregreview.org/2022/04/23/saturday-seminar-an-outer-space-perspective-on-climate-change/
[31] Martinez, L. F. Legal Regime sustainability in Outer space: theory and practice (Nov 1, 2019)
[32] Norms for outer space: A small step or a Giant leap for policymaking (Nov.3 01:29 AM) https://unidir.org/wp-content/uploads/2023/05/UNIDIR-Space_Dossier_7.pdf

charging fees to fund space debris cleanup have been frequently challenged as potential infringements on these fundamental space freedoms.

Article VI – The States are mandatory to oversee that the national space activities, including those of its nongovernmental entities, are conducted in accordance with international law.

Article VII – The launching state is liable for the damages that are caused by its space objects.

Article IX

The “due regard” obligation - State parties must conduct their space activities with due regard to the interests of other countries. This obligation, similar to the 'due regard' principle in maritime law, aims to balance competing rights. The extent of this obligation depends on factors like the nature of the rights, their importance, and the potential impact of the activities. Space debris, which hinders the fundamental right to explore and use space, requires a high level of due regard. While maritime law often interprets 'due regard' as a procedural obligation, the Outer Space Treaty has been interpreted to include a substantive dimension. This is linked to the 'no harm' principle, also outlined in the treaty.

The “no harm” rule - Article IX of the Outer Space Treaty requires countries to conduct space exploration without causing harm and to take necessary measures to prevent it. The treaty specifically mentions "exploration" but not "use," leading to debates about whether the rule applies to both. Additionally, it's unclear if space debris constitutes "contamination" under the treaty.

The Liability convention, 1972

The Liability Convention established on Article VII of the Outer Space Treaty, which states that the state parties which is launching space objects are liable for damage caused by those objects on Earth, in air space, or in outer space. The Convention further specifies liability based on where the damage occurs either on Earth's surface (Article II) or elsewhere (Article III).

Article II – States are absolutely liable for damages.

Article III – Principle of Fault Liability if the damage is caused anywhere outside the surface of the earth.

Article V – States are jointly and severally liable for damages caused by the space objects.[33]

Principle 21 of the Stockholm Declaration states that the states can use the resources to the full extent but no damage should be caused to the areas outside its control. A defunct satellite or space debris left in orbit violates the Outer Space Treaty because it doesn't benefit humanity; its presence doesn't serve the interests of all nations and it occupies space, which could be seen as a form of appropriation.[34]

7.3 United Nations Co- Sponsored Global Observing Systems

Global Climate Observing system (GCOS) established in 1992 to provide information on the climate change including its physical, chemical, and biological aspects, as well as its atmospheric, oceanic, hydrological, cryospheric, and terrestrial processes.[35]

Global Ocean observing system (GOOS) established in 1991 by the UNESCO IOC. Key climate change indicators like sea level, sea surface temperature, ocean colour, and sea ice extent are being monitored through the Global Ocean Observing System (GOOS)[36].

Global Terrestrial observing system (GTOS) established in 1996 and is led by Food and Agricultural Organisation of the United Nations (FAO)[37]. GTOS focuses on five issues namely changes in land quality; freshwater resources availability; pollution and toxicity; loss of biodiversity and Climate change[38].

The International Council for Science (ICSU) collaborates with UN organizations to address climate change using space technologies. The Committee on Space Research (COSPAR), established by ICSU in 1958, covers all disciplines of space research and discusses topics like

[33]ESIL Reflection – Clearing up the Space Junk – On the Flaws and Potential of International Space Law to Tackle the Space Debris Problem (Nov.3 10:14 AM) https://esil-sedi.eu/esil-reflection-clearing-up-the-space-junk-on-the-flaws-and-potential-of-international-space-law-to-tackle-the-space-debris-problem

[34] Regulating the Space Commons: Treating Space Debris as Abandoned Property in Violation of the Outer Space Treaty (Nov.3 12:30 PM) https://cjil.uchicago.edu/print-archive/regulating-space-commons-treating-space-debris-abandoned-property-violation-outer

[35] Global System for Sustainable Development (Nov.3 14:00 PM) https://gssd.mit.edu/search-gssd/site/global-terrestrial-observing-system-gtos-52742-mon-07-23-2012-0859

[36] Global Ocean Observing system (Nov.3 14:45 PM) https://goosocean.org/

[37] Space and climate change by UNOOSA

[38] Ibid.

Earth sciences, astronomy, planetary exploration, solar physics, plasma and magnetosphere studies, life sciences, microgravity and fundamental physics.[39]

8. SUGGESTIONS

Use of Greener propulsion technologies – The current propulsion technology that rockets use now has the rocket fuel composed of hydrazine and the potassium nitrate oxidant, which when burnt get converted into toxic gases. There are efforts into making better fuel such as Liquid Oxygen and Liquid Hydrogen which leave no residue behind when burnt, thus making the atmosphere cleaner.

Development of newer technologies – Use of Space elevators, electromagnetic accelerators, solar wind sails as alternate means to travel to space, being very different from traditional rockets will reduce the overall costs associated with travel to space as well as using less fuel.

Usage of alternative construction materials – Reducing the use of plastics in rocket manufacturing and opting for sustainably sourced materials like bio-plastics.

Reusability of launched rockets – Instead of manufacturing new rockets for every launch, opting for a reusable rocket will significantly reduce the cost. SpaceX's Falcon 9 is a reusable rocket.

These are few suggestions that already exist but are not being applied extensively. Apart from these suggestions any other suggestion that is more sustainable can also be adopted. Apart from these any other measures that can come up through scientific inventions will be much helpful in protecting this planet.

9. CONCLUSION

So, to conclude there is a need to reduce the climate change that is caused by space exploration which can be done by various means and to name a few, increasing the regulatory framework, limiting the space exploration, opting for renewable sources of energy and a comprehensive collaboration from all stakeholders towards sustainability to achieve climate justice. Technical innovation and ethical consideration need to be balanced so as to protect the space environment

[39] Ibid.

by integrating international cooperation, sustainable space exploration practices, waste management solutions and regulations to ensure that space activities do not harm the delicate ecosystems within our own planet. By adopting responsible practices like minimizing space debris, optimizing orbital resources, and conducting environmentally friendly space operations, we can safeguard the future of space exploration for generations to come.