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Futuristic Space Based AI Data Centre and its Legal Challenges and Environmental Impacts

Dr. Vijayalaxmi R. Shinde[1], Rajiv A. Shinde[2]

[1]Professor, Environmental Sciences, M.C.E. Societies Abeda Inamdar Senior College

Abstract

The proliferation of AI has increased the demand for huge data centers, raising major concerns over freshwater usage, energy, and carbon footprint. This way, space-based data centers have come as a response to traditional Earth-based ones, by possibly reducing environmental burdens. But environmental cost is still high in orbital domain. This study critically analyzes the environmental, legal, and ethical implications of those data centers. While there are ample solar energy and no dependency on land in outer space, new concerns are there. Constant satellite communication would cause electromagnetic radiation which damages ozone layer. Visibility of natural sky would also be reduced due to light pollution and orbital space would be even more congested.

There is a huge impact of these innovations, when it comes to transformation of outer space from shared to commercialized environment. This study also focuses of major gaps in existing global laws related to outer space in terms of cultural and environmental resource. It also explores rising concerns related to these developments and human rights, such as environmental rights and right to life to access untouched natural sky. With ethical critique, legal and sustainability analysis, this study has found that space-based data centers present complex challenges to the environment and regulatory bodies, despite being technically promising. This study recommends proactive frameworks to avoid compromising environmental balance while expanding AI infrastructure.

Keywords: Artificial Intelligence, space-based data centers, outer space, satellites, natural sky, orbital space, fundamental right, nocturnal species.

1. Introduction

It is very important to think beyond virtual and unreal nature of digitalization and focus on real-world impact when it comes to discuss legal aspects of artificial intelligence (AI) (Avanzini, 2019). As per their operational needs and composition, these technologies consume a lot of natural resources because of their high waste generation and huge energy metabolism, leading towards the generation of e-waste, which are environmentally damaging byproducts (Delle Cave, 2025). The carbon footprint of AI is not easy to estimate (Floridi, 2020). The AI data centers, which have storage servers and connection systems for uninterrupted supply of power to both software and hardware, are major factors from two major perspectives – (1) power consumption (to devices like hard drives, CPUs, and UPS, etc.; (2) water consumption (to cool down the servers at high temperatures; and (3) removal of non-functional, outdated, and decommissioned hardware from the data centers (Spencer and Singh, 2025)

Speaking of Space-based AI data centers, Elon Musk's SpaceX is the prime example which is taking over the planet with its xAI aka Grok chatbot. Its valuation is reportedly around $125 billion and SpaceX alone

stands at $1 trillion (Wang and Roulette, 2026). The deal of taking over xAI reflects his futuristic, strategic vision for technological advancement, along with merging his sprawling empire. This merger world builds an innovation engine which would place rockets, AI, media, and space-based internet at the same platform, according to Musk (Hays and Jamali, 2026). According to him, space-based AI would scale up space-based datacenters in future.

AI data center is developed to have specialized IT-based infrastructure which is needed to run, train, and deploy AI services and applications. It consists of advanced networking, storage, and computing infrastructure, apart from high-capacity cooling and power systems for intensive loads for AI. These datasets are designed for AI, cloud, and Machine Learning (ML) functions, which depend upon powerful "graphics processing units (GPUs)" instead of CPUs. More physical space is needed to deploy GPUs (Jonker and Gomstyn, n.d.). Organizations often depend on either colocation or hyperscale datacenters for loads on AI. In colocation, organizations lease servers, space, and bandwidth in hyperscale facilities, enabling organizations to access AI infrastructure without much investment (Jonker and Gomstyn, n.d.).

Unlike surface-based servers, orbital data centers operate in outer space. But they are concerning about transforming into technological and commercial aspects. Deployment of orbital data centers and satellite constellations has already started to alter electromagnetic and visual surrounding of Earth-like space. There are concerns rising about light pollution on visibility of night sky, carbon footprint of orbital space stations, and electromagnetic radiation from constant communication (Berger, 2026). There are several ethical and legal concerns raised by commercialized outer space. There is a lack of comprehensive legal framework to address space as shared cultural and environmental resource. It creates uncertainty related to issues like prolonged sustainability, environmental security, and equitable access (Economic Times, 2026).

Along with sustainability, this study critically examines whether space-based data centers provide genuine solution or adds another environmental cost to the Earth, while also determining their inferences for emerging environmental concerns.

1.1. Problem statement

AI has witnessed the rapid growth but it relies heavily on data centers, which consume a lot of power, leading to increasing concerns over freshwater usage, carbon emissions, and e-waste. There is a rise in space-based data centers as possible alternative to minimize carbon footprint. However, they add a lot of regulatory, legal, and governance issues. There is also a lack of comprehensive legal framework to evaluate feasibility apart from legal implications.

There is also a lack of legal understanding about status of outer space as cultural and environmental area. Existing frameworks don't address whether emerging artificial objects may conflict with right to life, collective access to natural sky, or environmental rights. It adds essential gap in knowledge of whether space-based infrastructure is an innovation or poses ethical and regulatory challenge.

1.2. Significance of the study

This study adds to the evolving discourse on AI data center (Figure1) with integration of environmental domain into the perspectives of human and legal rights, especially in terms of outer space. Unlike existing literature which focuses majorly on reducing carbon footprint and efficiency, this study sheds light on the need for regulatory and ethical concern over outer space. This study focuses on emerging concerns like space-based exposure to radiation (Figure2), light pollution, and possible understanding of night sky as shared heritage for policymakers, legal scholars, and researchers. It also gives the foundation to rethink global frameworks for managing space activities in terms of rising commercialization.

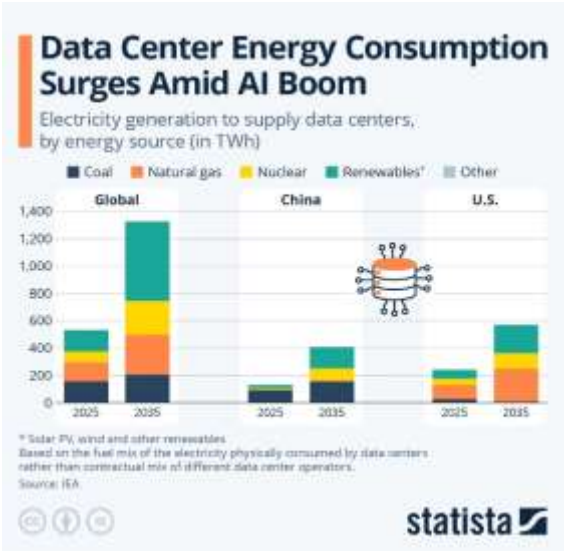

Figure1. Electricity Consumption

Figure2.Satellite Anomalies and Space Radiation

2. Literature Review

Zhuk (2023) identified hidden environmental costs related to implementation, elaboration, and development of AI technologies to ensure harmonious and sustainable adoption with several economic aspects by identifying political/legal and ethical/moral implications. They adopted ecological approach to implement and develop AI, along with political-legal and interdisciplinary analysis of environmental issues and algorithmic bias, decision-making processes which may cause injustice to the environment and environmental inequalities and errors in AI models. Additionally, analysis was conducted regarding the effects of destruction of natural ecosystem with the development of AI because of computing intensiveness of energy, rising effect of data centers on power consumptions, and issues with coding. It is found that a lot of energy is consumed by a lot of ethical, political-legal, and environmental issues related to use, training, and development of AI, especially from limited natural resources.

Ebert et al (2024) provided guidance on regulation based on climate for AI and data centers and explores

how to operationalize those needs. They also highlighted room for improvement and challenges, and make several policy proposals at the end. They proposed adoption of AI Act to report the energy consumption from AI which were once untapped. It is also observed that AI Act couldn't cover carbon emissions from applications of AI. Levels of measurement are compared in data centers and measures are recommended at server level for reporting energy consumption. For adoption of AI Act, it is also argued that environmental concerns are the part of risk assessment and provide suggestions on operationalization.

There are significant opportunities available to improve the reliability, efficiency, and cost-efficiency of distribution, management, and energy production with the rise in cloud technology and AI in renewable energy systems. These technologies enable predictive maintenance, enhanced decision-making, and real-time data analysis to manage variable resources. There is a need to explore ethical implications like privacy concerns, data security, and carbon footprint of cloud systems. Dibie (2024) analyzed these ethical issues with green data centers and AI-based smart grids. This case study has highlighted practical issues like data breaches, cyberattacks, sustainability and algorithmic biases. This study focuses on in-depth ethical framework based on transparency, fairness, and environmental responsibility to ensure the adoption of cloud and AI technologies in green energy.

Okereke et al (2025) provided in-depth analysis of international trends in sustainable infrastructure in data centers, while focusing on challenges, essential components, emerging trends, and regulatory models. Extensive literature review is employed based on reputable academic sources, case studies, and industry reports for evidence-based, robust analysis. As per the findings, data center is going through significant shift to achieve sustainability, based on combination of expectations of stakeholders, regulatory pressure, and technological advances. Adoption of green energy, energy efficiency, carbon management, water conservation, and circular economy were considered as important aspects of data centers.

Bhandari (2025) determines uneven effects of environment of AI data infrastructure in San Francisco (CA), Maricopa (AZ), and Loudoun (VA). This thesis identified major issues in current frameworks, which usually don't consider communities affected in decision-making or local realities. It also proposes framework based on stakeholders for integrating top-down regulation with bottom-up advocacy, providing more equitable and adaptive model for governance. With stakeholder analysis and case studies, study has also highlighted how regional differences, exclusion of procedure, and power imbalances shape environmental outcomes. At the end, this thesis proposed "AAI Mendelow Stakeholder Supplement (AIMSS)" to recenter stakeholder relationships and regional voices for more equitable and sustainable development of AI infrastructure.

2.1.Research Gap

Most of the studies were conducted on AI data centers focusing on sustainability, feasibility of technology, and power consumption, without concerning about space infrastructure. While some studies admit environmental benefits of orbital environment, critical analysis is needed about their secondary effects on the environment, such as, visual sky pollution and electromagnetic radiation. There is still need to explore ethical and legal implications to transform outer space into commercial infrastructure, especially related to environmental rights.

2.2.Research Objectives

As per the gaps identified, here are the objectives of the study –

- To conduct critical analysis on legal implications on orbital AI data centers
- To determine both celestial and global effects of space-based AI data centers

- To investigate rising concerns with space-based data centers like electromagnetic emission, space pollution, and light intrusion

3. Legal Implications on Orbital AI Data Centers

Satellites address most of the limitations related to surface-based data centers generated to fulfill rising usage of AI. But in case of orbital data centers, there is no restriction on land usage. In addition, there is more than enough cooling available in space and sunlight is an added plus for generating power. Along with keynote speeches, defense-tech and IT giants are already looking for systems to run and train AI models in space.

3.1.Licensing

A lot of commercial licenses use IP licenses over the universe, globally, or in all territories which are devised or known to evaluate the scope of rights, whether for media assets, datasets, training materials, or tech assets. Legally, satellites have their territories and nation-states on Earth. Legal regime is completely different in space, i.e., managed under the "1967 Outer Space Treaty", assigning control on the basis of country registering or launching the spacecraft and considering orbit as global commons (UN, 1967; Tronchetti, 2013).

3.2.Concerns over IP Violations

Traditional IP law is based on national boundaries and geographies. There are new concerns raised by satellite-based data centers. For example, application of new jurisdiction laws and what to do when someone produces illegal copy of copyrighted material. These legal concerns are further made complicated by space when it comes to data governance (Dinniss, 2016; Abbott, 2019). When inferences are drawn and AI data is trained from output from the satellite, there are some risks of infringement like (Tronchetti, 2013) –

- Country of registration
- Country of launching satellite
- Country of operating ground station
- Outer space doesn't fall under any sovereignty of the country
- Sender's location

3.3.Enforcement for Inspecting Satellite

IP implementation to deal with violation on earth depends upon tools like confiscation of hard drives, forensic imaging, onsite inspections, and detection of server logs. A satellite cannot be seized by any court order. It is not possible to inspect satellite hardware in orbit without specific spacecraft (Lyall & Larsen, 2018). From user's point of view, recovering logs may rely completely on operations performed by vendor. Even though access is promised by the organization, it may be prevented by global barriers related to jurisdiction or operational limitations. It creates the gap to discover law. Model checkpoints, logs, or evidence of training data might be present only on hardware that cannot be accessed by the user. It is also argued that there are safety or technical constraints in retrieving evidence (Dinniss, 2016).

3.4.Data Privacy

As there is no national territory for a satellite, clients may be held responsible for violating restrictions on cross-border transfer, especially when vendor cannot disclose that some AI operations take place in outer space and it may be subjected to possible liability of consumers, if AI vendor manages controlled data in orbit (Kuner, 2013). It raises concerns over the enforceability and scope of restitution for lawyers.

Organizations should update their data security needs, compliance audits, and privacy impact testing in contractual dealings and corporate transactions (Kuner, 2013; Abbott, 2019).

4. Celestial and Global Effects of Space-Based AI Data Centers

4.1.The "Heat Island" effect

Data centers which are developed for giving energy supply to train AI models produce a lot of heat. This heat is more than enough to raise surface temperature of the land by various levels which affect around 340 million people on earth. This phenomenon causes "heat island" effect of data centers. There would be a drastic rise of data centers built worldwide. A real estate giant, JLL has observed that capacity of data center would be almost double from 2025 to 2030, and AI would meet almost half the demand (Stokel-Walker, 2026).

Rather than storing in 19" racks, each server is stored and built around a "satellite bus", i.e., a space shuttle with large arrays of solar energy. These thermal systems handle heat and radiate away. Propulsion is built to maneuver and keep orbit. This is not a science fiction. It has become a reality. Starcloud has recently launched and altered Nvidia H100 Graphics processor to a small spacecraft to run Gemini in space[1]. However, hundreds of these satellites are needed to produce the output of even a single data center on Earth.

4.2.Economic Constraints

Building things on space is immensely expensive. The "International Space Station (ISS)" has almost the same amount of livable space as normal home in the US. But it still costs over $150 billion to build in space. It is around 1 million times the cost of a home for one family. Even a single kg of payload costs over $10,000 into orbit (Berger, 2026). SpaceX recently launched its 10,000th Starlink satellite. It is considered as another milestone in science and technology (Pearlman, 2026). However, photographer Joshua Rozells has captured something that concerning not only on economics side, which comes down to next major concern.

4.3.Light Pollution

Joshua Rozells captured 343 pictures in the timeframe of 85 minutes. He blended those images together with a low-light picture for the foreground. The highlights, contrast, and whites in the sky were elevated to underline the satellites. He used Photoshop to blend the trails of satellite and filled the gap between trails (Figure 3).

[1] Starcloud-1. Available at https://www.starcloud.com/starcloud-1

Figure 3 – A photograph of "Swamped Skies" by Joshua Rozells
Source – Growcoot (2026)

There are few restrictions when it comes to launch satellites, barring legitimate purposes. Space X and other tech giants have launched as many satellites as possible without much legal constraints. Majority of satellites are low-orbit to enable access to people in remote areas. They cause one serious kind of problem which is almost unnoticed by common people and media, i.e., light pollution. Light Pollution caused by satellite affects both astronomy and astrophotography. Due to this pollution, research becomes more time-consuming and reliability of telescope data is another concern. It is a concern which is getting worse if no measures for mitigating this challenge (Growcoot, 2026).

5. Concerns with Space-Based Data Centers

AI data centers have ever-growing and massive contributor to environmental pollution on surface. They are usually built in dry areas. They consume a lot of water and rely on all sources of energy like gas, oil, and renewables. As a result, they are responsible to generate a lot of pollutants, such as, greenhouse gases. Launching those facilities may not be a panacea for Earth-bound challenges. Actual environmental cost is very less nuanced conversation behind putting things in space. Maintaining those space stations and finally decommissioning them is very broad responsibility and extensive (Mowbray, 2026).

Spaceports are more likely to be located near coastlines and around the equator, which are adjoining areas rich in biodiversity and protected to cause harm to endangered wildlife species with tropical deforestation. According to researchers, proper knowledge of sustainable use of orbit should take place before any satellite deployment. Very clear idea is needed on tolerance level of atmosphere of space activity without affecting radiative balance and ozone layer. Earth's climate is already destabilized, which could be even worse when it impacts energy from the sun and outgoing energy (Mowbray, 2026).

Orbital data centers are widely explored to avoid the use of land, water, and energy by AI. They have also come up with new risks to overall wellbeing and rights of common people. While there is lower ecological footprint on planet, space-based AI data centers raise practical and ethical concerns about data sovereignty,

space debris, and resource usage (Dosunmu, 2026). Risk of collisions increase further by adding more satellites to Earth orbit, which is already congested. A chain reaction called "Kessler Syndrome" is created when multiple satellites are crashed, causing millions of space junks. These junks could damage GPS satellites, weather data, and comms, disrupting daily lives of people.

Space-based data centers could be a major risk to privacy and data sovereignty. Data stored on those satellites would not fall under any jurisdiction. So, it would be challenging to enforce any country's law or framework to private data. Rocket launches could also increase pollution, greenhouse gases, and emit black carbon to damage ozone layer. When it comes to decommission, these satellites are needed to be burnt up, which could cause more harm in the high atmosphere (Renzler, 2025).

6. Discussion and Conclusion

Space-based data centers have become a great innovation for mankind, but it also comes with a lot of terrestrial challenges. The in-space production of components for data center is another issue which further increases the concern. Heavy launch cost and including solar panels is another limiting factor when it comes to operate a huge data center. Eventually, operators may explore the production of in-space components, possibly using materials recycled from old satellites or gathered from celestial bodies. Majorly tech companies are responsible for rushing to space like land-based centers. Heavy maintenance and huge cost of launches may far outrun the benefits. They may put financial burden on taxpayers if governments invest heavily on these private projects.

1. Satellite constellation in lower orbital space will hinder to see space with added light radiation and may be moving bright satellite along with natural sky they will take away the right to see natural sky without considering human's fundamental right.
2. Disorients migratory birds, disrupts insect pollination, and upends predator-prey relationships. (darksky.org)
3. Satellite emissions are roughly 500 times more effective at warming than the same particles released at the surface. Reentering satellites are depositing enough aluminum into the upper atmosphere to rival the contribution from natural meteors. (Astronomy, Connor Barker)
4. Regulatory gap, in 1986, the commission established a categorical exclusion for satellite licensing under the National Environmental Policy Act (NEPA), effectively exempting launches from environmental review. Under NEPA, an agency can override such an exclusion if it identifies an "extraordinary circumstance" — a situation where the environmental impact may be significant enough to warrant a closer look. (Astronomy.com)

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28. Ai Data Center Electricity Consumption - Search
29. New satellite constellations could ruin the night sky, astronomers warn
30. Statistical Analysis of LEO and GEO Satellite Anomalies and Space Radiation