



Research Paper

**Toward an equitable governance of space resources: A policy-oriented framework
for sustainability and resilience**

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Abstract. As human activities expand across Earth orbit, the Moon, and other celestial bodies, the governance of critical space resources has become a pressing issue, exposing persistent gaps in current international regulatory mechanisms. This paper advances a policy-oriented vision for equitable and resilient space governance, grounded in sustainability principles and ethical imperatives. Through the lens of key domains—ranging from spectrum allocation and orbital debris mitigation to planetary surface rights and data governance—it explores how the discourse on space resources reveals deeper challenges for multilateral coordination, institutional leadership and strategic foresight in a multipolar world. The study underscores the need for adaptive international frameworks that align with both technological advancements and shifting geopolitical conditions. It outlines a set of core principles for inclusive governance and advocates for strategic leadership and global partnerships to operationalize this vision. Drawing on the policy outlooks of key global and regional actors—including the European Union, the United Nations system, and leading space policy institutes—it calls for a globally engaged, integrative and forward-looking governance vision for outer space.

Keywords: Space governance, sustainability and resilience, planetary stewardship, space resource regulation, international space policy.

Araştırma Makalesi

**Uzay kaynaklarının adil yönetişimine doğru: Sürdürülebilirlik ve dirençlilik odaklı
bir politika çerçevesi**

Öz. Dünya yörüngesi, Ay ve diğer gök cisimlerinde insan faaliyetlerinin artmasıyla birlikte, kritik uzay kaynaklarının yönetişimi acil bir mesele haline gelmiş; mevcut uluslararası düzenleyici mekanizmalardaki kalıcı boşlukları gözler önüne sermiştir. Bu makale, sürdürülebilirlik ilkeleri ve etik zorunluluklar temelinde şekillenen, adil ve dirençli bir uzay yönetişimi için politika odaklı bir vizyon sunmaktadır. Spektrum tahsisi ve yörünge enkazının azaltılmasından gezegen yüzey haklarına ve veri yönetişimine kadar uzanan temel alanlar çerçevesinde, uzay kaynakları etrafındaki söylemin çok kutuplu bir dünyada çok taraflı koordinasyon, kurumsal liderlik ve stratejik öngörüye dair daha derin zorlukları nasıl ortaya koyduğunu incelemektedir. Çalışma, hem teknolojik ilerlemelerle hem de değişen jeopolitik koşullarla uyumlu, uyarlanabilir uluslararası çerçevelerin gerekliliğini vurgulamaktadır. Kapsayıcı yönetim için temel ilkeleri ortaya koymakta ve bu vizyonun hayata geçirilmesi adına stratejik liderlik ile küresel ortaklıkları savunmaktadır. Avrupa Birliği, Birleşmiş Milletler sistemi ve önde gelen uzay politika enstitüleri gibi küresel ve bölgesel aktörlerin politika yaklaşımlarından yararlanarak, dış uzay için küresel ölçekte etkin, bütüncül ve geleceğe dönük bir yönetim vizyonu çağrısında bulunmaktadır.

Anahtar Kelimeler: Uzay yönetişimi, sürdürülebilirlik ve dirençlilik, gezegensel sorumluluk, uzay kaynaklarının düzenlenmesi, uluslararası uzay politikası.

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1. INTRODUCTION

The rapid expansion of space activities, driven by both governmental and commercial initiatives, has heightened the urgency of regulating access to and the use of space resources. From spectrum management to planetary surface rights, the legal and policy frameworks surrounding these resources remain fragmented. With the increasing intensity of activity in Low Earth Orbit (LEO), the launch of lunar exploration programs, and the emergence of In-Situ Resource Utilization (ISRU) ventures, a robust and cooperative regulatory architecture is essential to prevent conflict, ensure safety, and promote sustainability.

Simultaneously, as states become more reliant on space-based infrastructure for communication, navigation, environmental monitoring, and crisis response, resilience emerges as a necessary complement to sustainability. Space systems must not only endure but also adapt, recover, and continue operating under stress or disruption (Jakhu et al., 2017), (Tronchetti, 2015).

International efforts led by actors such as the United Nations Office for Outer Space Affairs (UNOOSA), the Organization for Economic Co-operation and Development (OECD), and the Hague International Space Resources Governance Working Group demonstrate the global policy interest in shaping the future governance of space resources. However, diverging national practices—particularly the emergence of national space resource legislation—and contrasting normative visions among stakeholders complicate consensus-building. These tensions underscore the need for a cooperative, yet adaptive, governance model that acknowledges both legal pluralism and geopolitical realities (United Nations Office for Outer Space Affairs, n.d.), (OECD, 2019), (OECD, 2020), (The Hague WG, 2020).

Given the increasingly pluralistic legal environment, the emergence of a single, universally binding regime appears unlikely in the near term. Instead, governance norms are being formed incrementally through a patchwork of national initiatives, multilateral dialogues, and non-binding instruments. Each trajectory favors particular actors and value systems, influencing outcomes for governments, private sector players, and multilateral institutions alike. This evolving governance landscape reinforces the importance of shared principles—such as equity, sustainability, and resilience—as stabilizing anchors amid competing interests and asymmetries.

The 2023 UNOOSA report on space resource activities highlights the persistent divergence in national interpretations and legal positions among Member States, particularly concerning the relationship between Article II of the Outer Space Treaty and the permissibility of resource extraction (United Nations Office for Outer Space Affairs, 2023). While consensus exists around the principle of non-appropriation of celestial bodies, divergent approaches to licensing, registration, and benefit-sharing expose a legal grey zone within the evolving space economy.

Importantly, the report cautions that existing international treaties do not explicitly regulate the extraction and utilization of space resources, leaving significant gaps in enforcement, liability, and equitable access. It further notes that Member States have not reached agreement on whether additional legally binding instruments are required, or if soft-law approaches suffice for the time being. In response to these regulatory gaps and uncertainties, a proposal for an 18th Sustainable Development Goal (SDG) explicitly targeting outer space has been advanced. Although not yet adopted, this proposal signifies the increasing recognition of outer space as a vital domain requiring effective regulation for sustainable development (Losch et al., 2024).

Global space governance must evolve to reflect the growing importance of space as a strategic enabler of societal resilience, economic transformation, and planetary stewardship. While several regional and thematic frameworks have begun to acknowledge these imperatives, many fall short of delivering globally actionable mechanisms. Nonetheless, they offer valuable reference points by embedding responsible principles and cooperative norms.

For instance, the European Union's Space Strategy for Europe and the proposed EU Space Act call for a unified legal approach that enhances safety, resilience, and sustainability (European Commission, 2025), (European Commission & High Representative of the Union for Foreign Affairs and Security Policy, 2023). These initiatives aim to harmonize regulatory practices across Member States by promoting a single market for space activities, enabling commercial actors to operate across borders within a consistent, transparent, and secure legal environment. They also introduce mandatory licensing, debris mitigation standards, and resilience safeguards for critical space services—elements that could serve as foundational components of broader international governance models.

The ESPI2040 report (European Space Policy Institute, 2022), a regionally influential and forward-looking strategic framework, recognizes space not merely as an economic sector, but as a foundation for integrated progress across climate, defense, energy, digital infrastructure, and beyond. Expanding upon such initiatives, an inclusive global governance framework should strike a careful balance between innovation and responsibility, grounded in the principles of equity, transparency, and adaptability. This approach can leverage European policy thought leadership as a reference point, while advancing cooperative governance models aligned with the realities of a multipolar world—where diverse state and non-state actors share responsibility for sustaining space as a global commons.

This perspective also aligns with key multilateral instruments such as the Outer Space Treaty (United Nations, 1967), the Long-Term Sustainability Guidelines (United Nations Office for Outer Space Affairs, 2019), and even underutilized frameworks like the Moon Agreement (United Nations, 1979)—each contributing to a foundation for building international consensus. High-level political dialogues, including the G20 Space Economy Leaders Meetings, further reflect a growing global appetite for cooperative regulation. By integrating these efforts into a forward-looking global framework, space governance can transition from aspirational declarations to operational mechanisms.

This paper draws on a qualitative review of treaties, policy instruments, and expert literature. It proceeds as follows: Section 2 discusses sustainability frameworks for space resource utilization; Section 3 addresses resilience in governance frameworks; Section 4 outlines key regulatory challenges; Section 5 explores enabling and disruptive technologies; Section 6 proposes core principles; Section 7 presents strategic governance pillars; Section 8 discusses leadership and global partnerships; and Section 9 concludes with space policy recommendations.

2. SUSTAINABILITY IN SPACE RESOURCE UTILIZATION

Sustainability, in the context of space resources, refers to the responsible and long-term use of outer space assets, ensuring that today's activities do not compromise the ability of future generations to access and benefit from these resources. This encompasses the sustainable extraction and utilization of space-based materials, the active mitigation of orbital congestion, and the protection of celestial environments from irreversible harm. Achieving sustainability requires binding multilateral agreements, robust compliance mechanisms, and shared technological standards that emphasize preservation and stewardship over short-term commercial gains.

Global discussions on sustainability increasingly focus on critical issues such as orbital debris mitigation, the protection of scientific heritage sites (e.g., the Apollo landing zones), and equitable access to and benefits from space-derived data. The United Nations' Long-Term Sustainability Guidelines (LTSGs), endorsed by the Committee on the Peaceful Uses of Outer Space (COPUOS), provide a widely recognized—though non-binding—baseline for advancing sustainable space practices at the international level (United Nations Office for Outer Space Affairs, 2019), (Aliberti et al., 2023).

In a broader context, the ESPI vision stands out as it advances a more expansive understanding of sustainability by linking space governance to planetary objectives, including the European Green Deal, Net-Zero targets, and the UN Sustainable Development Goals (SDGs). It highlights the transformative role of space-based capabilities—particularly Earth Observation, Positioning, Navigation and Timing (PNT), and SATCOM—in supporting sustainable agriculture, mobility, energy systems, and climate-resilient cities. Sustainability must also guide the design of next-generation space infrastructure, including low-impact satellites and space-based solar power systems, aligning technological progress with ecological and ethical standards.

Ensuring sustainability in the evolving NewSpace ecosystem necessitates the extension of international norms and standards to include non-traditional actors. Mechanisms such as public-private collaboration, voluntary codes of conduct (Chrysaki, 2020), extended licensing protocols (Reif, 2002), and shared stewardship agreements are essential to prevent commercial momentum from outpacing collective stewardship and global governance capacity.

While sustainability safeguards the long-term viability of space activities, resilience ensures their functionality amid disruption. Together, they form the dual pillars of a responsible, future-proof space governance paradigm. Emerging technologies—discussed in Section 5—such as AI-enabled debris mitigation and blockchain-based registries, offer practical tools to help operationalize sustainability measures.

3. INTEGRATING RESILIENCE INTO SPACE GOVERNANCE

Resilience complements sustainability by focusing on the ability of space systems, policies, and infrastructures to withstand and recover from disruptions—whether due to natural phenomena, operational accidents, or geopolitical

tensions. As space becomes an essential domain for communications, navigation, and security, ensuring resilience requires the strategic planning of redundancies, the cultivation of international collaboration, and the development of response strategies for systemic shocks.

A global vision for space governance must emphasize resilience not only in infrastructure but also in policy and strategic decision-making. It entails strengthening institutional capacity, diversifying and federating industrial supply chains, and building robust education and talent pipelines. A resilient space ecosystem must be capable of withstanding economic and political volatility, fostering innovation under uncertainty, and securing independent access to critical technologies.

This includes resilience in:

- Infrastructure: Redundant satellite constellations and modular space stations;
- Governance: Institutions capable of adapting to emerging threats or technological shifts;
- Legal frameworks: Norms and agreements that remain robust as commercial and geopolitical conditions evolve.

Embedding resilience into regulatory discourse ensures that space activities are not only sustainable in principle but also viable in practice when confronted with unforeseen challenges. This contributes directly to the long-term stability of the space environment. The protection of critical infrastructure—such as navigation satellites, communication relays, and climate-monitoring platforms—is vital to both national security and global welfare. Establishing multilateral early warning systems for potential cyberattacks, collisions, or hostile interference would enhance collective resilience. Such systems must be framed not only as technical safeguards, but also as instruments of space diplomacy—upholding human rights and ensuring equitable global access to essential services for all.

A practical example of resilience-oriented governance is the European Space Agency's Space Safety Programme (European Space Agency, 2023), which addresses hazards ranging from space weather and near-Earth objects (NEOs) to orbital debris and re-entry risks. The programme embodies a proactive, systems-level approach to risk mitigation through international data sharing, multi-domain monitoring, and autonomous decision-support mechanisms. Such initiatives provide operational blueprints for mainstreaming resilience into space governance frameworks.

Complementing this operational approach is the normative vision advanced by the Space Renaissance Initiative (SRI), which promotes a humanist ethos for space development—emphasizing equity, sustainability, and the long-term expansion of human civilization beyond Earth not only as a scientific or economic imperative, but as a moral one (Space Renaissance Initiative, 2016). Echoing Enlightenment ideals and the concept of an 'Open World,' the SRI advocates for a cultural and philosophical renaissance that frames outer space as the next frontier for realizing humanity's ethical expansion and planetary resilience. From this standpoint, outer space is not merely a realm of extraction or competition, but one of shared human responsibility—where resilience is most effectively amplified through practical commitments such as interoperable infrastructure, transparent data systems, and collective preparedness platforms made accessible to all through multilateral cooperation.

4. REGULATORY CHALLENGES IN CRITICAL RESOURCE DOMAINS

As space activities expand across orbital, cislunar, and planetary environments, regulatory frameworks are under mounting pressure to adapt. The proliferation of NewSpace actors, the diversification of mission profiles, and the emergence of contested operational domains demand proactive legal and governance responses. This section outlines key regulatory challenges in managing critical space resources—including electromagnetic spectrum coordination, orbital traffic control, planetary protection, surface rights, and data governance. Addressing these challenges is essential to ensure coherent and enforceable legal frameworks in an increasingly complex space ecosystem.

4.1. Spectrum Allocation and Coordination

The electromagnetic spectrum is a finite and increasingly congested resource that is essential for satellite communications. The International Telecommunication Union (ITU) allocates global radio frequencies and satellite orbits through coordination among Member States to prevent harmful interference (International Telecommunication Union, 2020). However, the surge in NewSpace actors and the deployment of mega-constellations have significantly intensified spectrum competition. This trend raises critical concerns regarding

equitable access, dynamic spectrum sharing protocols, and protection from cross-service interference. Incorporating ITU-R regulations, spectrum priority rights, and the outcomes of World Radiocommunication Conferences (WRC) into broader coordination frameworks is vital. As cislunar and deep space missions continue to expand, forward-looking spectrum governance must prioritize interoperability and open data access across operational domains.

4.2. Orbital Debris and Traffic Management

The increasing risk of collisions in LEO necessitates robust space traffic management (STM) policies, underpinned by comprehensive Space Situational Awareness (SSA) capabilities. The Inter-Agency Space Debris Coordination Committee (IADC) (Inter-Agency Space Debris Coordination Committee, 2021) provides technical guidelines for debris mitigation; however, these remain non-binding. The U.S. Space Policy Directive-3 and European Space Agency (ESA)'s Clean Space initiative represent steps toward operational STM frameworks (White House, 2018), (European Space Agency, 2022), yet they lack international enforceability. Effective STM must include pre-launch registration, conjunction assessment standards, post-mission disposal protocols, and real-time deconfliction procedures. As commercial NewSpace activity accelerates, a globally harmonized STM regime—particularly for shared orbital shells—will be critical to ensuring long-term sustainability.

4.3. Lunar and Planetary Surface Rights

The Outer Space Treaty (1967) prohibits national appropriation of celestial bodies (United Nations, 1967), yet it remains silent on the extraction of space resources. The Artemis Accords (NASA, 2020) support the utilization of resources such as lunar water ice and asteroidal minerals under the framework of international law, but they have not achieved universal acceptance. This legal gap creates uncertainty for both public and private actors planning in-situ resource utilization (ISRU) missions. Key regulatory concerns—also raised by the Moon Village Association (MVA) and other stakeholders—include legal certainty, resource claim notification procedures, and the protection of heritage sites such as the Apollo landing zones (Moon Village Association, 2020). With rising interest in cislunar infrastructure, coordinated multilateral frameworks will be essential to prevent territorial disputes and safeguard non-discriminatory access.

4.4. Access to Lagrange Points

Lagrange points such as Earth–Moon L1 and L2 are strategic quasi-stable zones valuable for scientific observatories, refueling depots, and deep space relay stations. Although no formal regime currently governs their use, proposals have been made to treat them as limited commons requiring cooperative management (Boley & Byers, 2021). As lunar orbital and transfer infrastructure expands, regulatory issues such as station-keeping rights, shared access protocols, and mission interference thresholds will require international attention. Anticipatory regulation will be essential to prevent monopolization or congestion of these high-value gravitational zones.

4.5. Environmental Protection of Celestial Bodies

The COSPAR planetary protection guidelines aim to prevent biological contamination of celestial bodies (COSPAR, 2021). However, these standards were designed primarily for scientific missions and may fall short in effectively regulating commercial-scale space activities. A multilateral preservation regime should address both forward and backward contamination, incorporate planetary protection Category IV classifications, and support astroecological assessments. Balancing scientific access, environmental stewardship, and the rights of NewSpace actors will be essential to uphold the intrinsic value and biological integrity of extraterrestrial environments.

4.6. Human Safety in Lunar and Orbital Habitats

With human outposts becoming viable in orbital, lunar, and deep space environments, globally harmonized standards for life support, crew safety, and emergency response will become essential. NASA's Human Exploration and Operations Mission Directorate and ESA's Space Safety Programme represent initial steps toward the development of coordinated human safety frameworks for space infrastructure (NASA, 2021), (European Space Agency, 2024). Future regulatory efforts should address radiation dose limits; habitat protocols across in-space, lunar, and LEO environments (ISLEO); crew conduct codes; and dual-use emergency response procedures. The growing convergence of commercial, governmental, and international actors underscores the need for a shared human safety baseline.

4.7. Intellectual Property and Data Rights

As NewSpace actors increasingly contribute to space exploration and data generation, issues surrounding Intellectual Property Rights (IPR) and data sovereignty raise complex jurisdictional challenges. The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) provides a global framework for IP protection, but its applicability to outer space remains unsettled (von der Dunk, 2019). Policymakers must balance incentives for innovation with obligations to open science and the stewardship of space as a global commons. Key considerations include the extraterritoriality of IPR, dual-use data governance, and the preservation of space-derived knowledge as a shared public good.

Clear and cooperative governance mechanisms are needed to support the sustainability of these intangible space resources in response to growing commercial and scientific activity. As rapid technological progress continues to outpace the evolution of international norms and institutions, proactive and inclusive policymaking will be essential to reconcile national interests with collective responsibilities in the space domain. Balancing rapid technological progress with the slower evolution of international norms and institutions remains a key challenge; proactive and inclusive policymaking will be essential to align national interests with collective responsibilities in the space domain.

5. EMERGING ENABLERS AND DISRUPTIVE TECHNOLOGIES

The convergence of digital, biological, and physical technologies is reshaping how space resources are accessed, governed, and utilized. As Artificial Intelligence (AI), High-Performance Computing (HPC), blockchain, quantum communication, and digital twins advance across the space sector, their implications for sustainability, resilience, and equity are profound. These technologies offer significant promise—enabling autonomy, operational efficiency, and mission safety—but they also introduce complex legal, ethical, and strategic challenges that existing regulatory frameworks are ill-equipped to handle.

AI and HPC facilitate onboard autonomy, predictive analytics, and the real-time processing of massive datasets, transforming space traffic coordination, anomaly detection, and mission planning. In combination with edge computing architectures, these tools are essential for autonomous surface operations on the Moon or Mars, while also enhancing their operational capacity on Earth through advanced remote sensing and Earth observation applications. To effectively manage these advanced capabilities, regulatory frameworks must clearly define liability and accountability rules for AI-driven decisions, particularly those affecting collision avoidance, orbital management, and overall system resilience.

Blockchain technologies present new opportunities for transparent registries, supply chain verification, and secure data provenance—particularly relevant in distributed and multi-stakeholder mission contexts. To fully realize these benefits, blockchain governance will require new international agreements that standardize the cross-border recognition of distributed registries and clearly define their legal validity.

Quantum communication, another emerging enabler, introduces ultra-secure links for critical navigation, reconnaissance, and command-control systems. However, its integration into space systems also presents novel geopolitical challenges related to technological disparities and verification protocols. Therefore, international agreements must proactively establish clear standards for quantum encryption to mitigate potential geopolitical tensions stemming from asymmetric secure communication capabilities.

Digital twins and bio-regenerative systems enhance risk mitigation and long-duration habitability by providing immersive simulation environments for operational rehearsals and closed-loop life-support management. These advanced tools are instrumental for building resilient cislunar infrastructure and future deep-space outposts, significantly strengthening mission safety, sustainability, and operational efficiency.

However, governance mechanisms must anticipate and embed principles of accountability, safety, and equity. Issues such as explainability in AI, liability in autonomous systems, and equitable access to enabling digital infrastructure demand urgent multilateral attention. A global, anticipatory governance approach is essential to ensure that emerging technologies reinforce shared norms rather than entrench asymmetric access or control over space-derived value.

A particularly salient dimension concerns AI-generated knowledge (European Parliament and Council, 2024). HPC and machine learning models increasingly derive insights from raw telemetry and sensor data, raising unresolved questions of intellectual property, jurisdiction, and attribution. As this fast-paced digital transformation unfolds,

regulators must address the ownership of AI-derived outputs, accountability in automated decision-making, and the cross-border enforceability of space data rights.

In summary, emerging enablers necessitate policymakers to move beyond reactive rulemaking toward foresight-based governance. This includes engaging expert communities, developing testbeds, and codifying interoperability standards. These technologies must be incorporated into governance frameworks from the outset—not retrofitted after deployment. Expanding on initiatives like the EuroMoonMars field campaigns (Foing et al., 2022) can inform these discussions by offering simulated environments to test emerging technologies and foster innovation in the space sector—generating insights directly applicable to anticipatory policy development. By embedding technological enablers within a shared vision for responsible innovation, the global space community can ensure that disruption leads to collective benefit rather than systemic fragmentation.

6. PRINCIPLES FOR EQUITABLE AND INCLUSIVE SPACE GOVERNANCE

In parallel with foundational instruments such as the Outer Space Treaty (1967) and the Moon Agreement (1979), a new wave of national legislation—such as the U.S. Commercial Space Launch Competitiveness Act (2015) (United States Congress, 2015), Luxembourg’s Space Resources Law (2017) (Government of Luxembourg, 2017), and the United Arab Emirates’ Federal Law No. 12 (2019) (United Arab Emirates, 2019)—demonstrates a deliberate move by individual states to establish domestic legal clarity regarding space resource utilization. While generally consistent with the Outer Space Treaty’s permissive framework, these unilateral initiatives signal the emergence of a fragmented legal landscape.

Several international efforts have sought to bridge this emerging normative divide. Notably, The Hague International Space Resources Governance Working Group (2015–2020) proposed a set of Building Blocks intended to promote shared principles without imposing binding obligations. Similarly, UNOOSA’s Legal Subcommittee has facilitated ongoing discussions, acknowledging both the potential and legal complexity of off-Earth resource extraction (United Nations Office for Outer Space Affairs, n.d.). The OECD Space Forum has likewise examined the economic and policy dimensions of resource activities beyond Earth (OECD, 2019).

These multilateral initiatives highlight the difficulty of reconciling commercial imperatives with collective governance. The diversity of stakeholders involved—ranging from national governments and private industry to civil society—further complicates the path toward a single, unified global regime. Instead, these developments point to the need for a pluralistic yet principled approach: one that acknowledges legal diversity while advancing equitable access, transparency, and accountability at international level.

A credible and effective regulatory vision must be anchored in universally shared principles: inclusivity, transparency, interoperability, accountability, and stewardship. As governance mechanisms evolve, they must support equitable access for emerging space nations and private actors alike. International frameworks should avoid both legal ambiguity and regulatory capture, while providing clarity, predictability, and stability to all stakeholders.

Equity demands more than mere access alone; it entails inclusive representation in agenda-setting, norm development, and benefit-sharing. Global leadership should advance capacity-building initiatives, open standards, and shared research and development/innovation (R&D/I) platforms. The principle of stewardship must guide resource utilization, ensuring that today’s exploitation does not foreclose opportunities for future generations.

Inclusivity must also confront structural disparities across gender, generation, geography, and socio-economic status. Transparency fosters institutional trust, while interoperability enables seamless cross-border technical collaboration. Legal and institutional accountability reinforces these principles by ensuring that all actors are held responsible for their actions.

6.1. Core Principles of Equity

- **Intergenerational Justice:** Space activities must consider the long-term sustainability of the orbital environment and celestial bodies, ensuring that opportunities remain available for future generations.
- **Proportionality and Capacity:** Rules and responsibilities must reflect the differing capabilities of spacefaring and non-spacefaring nations, without excusing inaction or diminishing shared responsibilities.
- **Common Benefit Doctrine:** Building upon Article I of the OST, the use of outer space must serve the interests of all humankind, supported by mechanisms that enable equitable access to data, resources, and economic returns.

6.2. Mechanisms to Enable Fair Participation

- **Open Access Registries:** Establish transparent and internationally accessible registries for resource claims, orbital slot allocations, and lunar surface activities to promote accountability and mitigate geopolitical tensions.
- **Benefit-Sharing Models:** Formulate international agreements that mandate a portion of the economic returns from space resources be allocated toward global development goals or shared technology programmes.
- **Global Commons Framework:** Designate certain domains, such as Lagrange points, polar lunar regions, or high-value orbits, as common heritage areas with specific protections and cooperative usage regimes.

6.3. Governance Integration

- Ensure that space governance is integrated into broader discussions on sustainability, resilience, and socio-economic justice. This includes aligning policies across interrelated domains such as climate change adaptation, disaster risk management, digital infrastructure, and energy transitions.
- Promote joint initiatives between space and non-space sectors to ensure that regulatory evolution reflects real-world interdependencies, such as satellite-enabled smart agriculture, resilient supply chains, and secure digital connectivity.

6.4. Multilateralism and Institutional Anchoring

- Strengthen the role of international bodies such as the UN Committee on the Peaceful Uses of Outer Space (COPUOS), ITU, and UNOOSA in setting norms, facilitating dispute resolution, and fostering inclusive multilateral dialogue.
- Establish pathways for greater involvement of non-traditional actors (e.g., Global South, indigenous communities, private sector) in the shaping of international space law and governance.

These principles provide the ethical and operational foundation upon which a globally legitimate and forward-looking governance framework can be built. Collectively, they form the normative guidance and ethical compass for the strategic governance pathways explored in the following section.

7. A GLOBAL GOVERNANCE PROPOSAL FOR SPACE RESOURCES

As space becomes a critical domain underpinning economic development, environmental monitoring, scientific advancement, and global security, the imperative for a unified, anticipatory, and adaptive global governance model grows stronger. The current landscape—characterized by fragmented regulatory regimes and asymmetrical capabilities—risks exacerbating global inequalities and compromising the long-term sustainability of outer space.

This paper advances a governance vision centered on four strategic pillars:

- **Equity and Inclusiveness:** Ensure that both spacefaring and non-spacefaring nations have a meaningful voice in rule-making processes and equitable access to the benefits derived from space resources.
- **Resilience and Adaptability:** Promote legal and institutional frameworks capable of evolving alongside rapid technological and geopolitical changes, including the rise of new actors and new domains (e.g., in-orbit servicing, lunar ISRU).
- **Integrated Multilateralism:** Advocate for governance mechanisms that are embedded across policy sectors—linking space with climate, energy, health, mobility, and security—and anchored in transparent and inclusive multilateral institutions.
- **Responsible Leadership and Capacity Building:** Call upon leading space actors to assume stewardship roles in facilitating technology transfer, developing global public goods, and supporting emerging space nations through open standards and cooperative missions.

Such leadership must also extend to the development of shared security protocols and early-warning systems. These measures are essential to protect critical space infrastructure—such as navigation, communications, and Earth observation assets that underpin essential services and global stability. Framing these efforts as part of a global commons protection agenda reinforces the responsibility of space actors to uphold human rights and ensure the uninterrupted provision of public goods worldwide.

This governance vision is not yet realized. The present study aims to initiate this global dialogue, advocating for coordinated leadership, partnership-based diplomacy, and a renewed mandate for international institutions such as COPUOS, ITU, and UNOOSA to serve as central platforms for implementing shared space governance goals.

8. RESPONSIBLE LEADERSHIP AND GLOBAL PARTNERSHIPS

Beyond norms and protocols, the space domain urgently needs visionary leadership. States and international bodies must spearhead a new governance paradigm that is anticipatory, cooperative, and anchored in shared global values. This includes the development of shared security protocols and early-warning systems to safeguard critical infrastructure as global commons, thereby reinforcing the space sector's vital role in protecting human rights and ensuring the continuity of essential public services worldwide.

In shaping this vision, European policy thought leadership offers valuable normative and institutional precedents. Although tailored to its regional context, the European approach rooted in precautionary environmental principles, multistakeholder governance models, and an emphasis on peaceful cooperation can serve as a strong reference point for building globally inclusive governance frameworks that balance innovation, responsibility, and equity.

Achieving equity in space governance requires a careful balancing of national interests, commercial freedoms, and collective planetary stewardship. Establishing global partnerships and exercising responsible space leadership must go hand in hand with the co-creation of soft law instruments, the strengthening of verification and enforcement mechanisms, and the strategic use of multilateral forums to bridge geopolitical divides. The establishment of open registries, community-led oversight bodies, and public interest safeguards can reinforce legitimacy and accountability. These partnerships must not only formulate policy but also deliver impact through interoperable standards, shared monitoring mechanisms, and equitable access to strategic infrastructure.

Building on these collective efforts, a future-proof model of space governance can emerge—capable of shaping responsible global norms through inclusive practices and shared principles, even in the absence of universal jurisdiction.

9. CONCLUSION

This paper advocates for a bold global vision: a space governance architecture that is cooperative, adaptive, and inclusive—anchored in human rights, scientific responsibility, and long-term planetary stewardship. Achieving this vision requires prioritizing global partnerships that effectively integrate governmental leadership, commercial innovation, civil society oversight, and academic expertise in a coordinated and strategic manner.

Space domain expertise must serve as the foundation of policymaking and be integrated in both transdisciplinary and interdisciplinary ways to avoid superficial or siloed approaches driven by actors lacking technical understanding. Instead, co-created, overarching governance models are needed—ones that reflect the diverse and inclusive narratives of a broad range of stakeholders and promote systemic connectivity across sectors and disciplines. Such an approach must also evolve in tandem with the new wave of technological convergence reshaping the space domain—from artificial intelligence and quantum technologies to biotechnology and digital infrastructure—which is redefining how space resources are accessed, governed, and utilized.

While regional frameworks remain limited in scope, they can serve as testbeds for governance innovation. In this context, European policy models grounded in multilateralism, safety-first principles, and regulatory coherence offer valuable precedents that can inform global frameworks. Although tailored to their specific local contexts, such initiatives highlight the potential of regionally tested, globally relevant standards to serve as stepping stones toward a more inclusive and enforceable international governance architecture.

This vision calls upon leading space nations, institutions, and commercial actors to assume proactive stewardship roles in shaping a globally inclusive, sustainable and resilient future. It involves co-creating frameworks for technology transfer, shared infrastructure, and open access to space-derived public goods, particularly in support of emerging space nations. Central to this vision is the establishment of shared security protocols and multilateral early-warning systems that protect critical infrastructure as global commons, upholding not only the stability of the space environment but also the continuity of public services and human rights worldwide.

By embedding equity and solidarity into cooperative missions, open standards, and multilateral engagements, global stakeholders can co-create a future-proof space governance model—one that fosters an inclusive ecosystem

where the benefits of space are equitably accessible and resilient across regions, generations, and geopolitical boundaries.

Scope and Limitations:

This paper does not seek to provide a definitive legal regime or comprehensive institutional architecture. Rather, it offers a structured policy vision rooted in equity, ethical governance, and anticipatory resilience. Legal and institutional references are included to contextualise—not resolve—the current regulatory dynamics, and are by no means exhaustive.

Instead, it adopts a novel integrative framing that treats sustainability and resilience as mutually reinforcing grounding principles—positioned not merely as thematic goals, but as actionable pathways for aligning diverse stakeholders across sectors and jurisdictions. By coupling long-term planetary stewardship with adaptive governance capacities, this dual lens facilitates the emergence of inclusive and future-proof regulatory approaches.

Importantly, this contribution also serves as a precursor study to gauge interest and identify potential collaborators for further elaborating the proposed vision. It aims to inform and inspire policy dialogue toward identifying strategic pathways and co-creating practical governance models and regulatory frameworks, whilst supporting the long-term evolution of cooperative, inclusive, and future-ready space governance.

ETHICAL STATEMENT & GENERAL STATEMENTS

This paper meets the standards of research and publication ethics.

AUTHORS' CONTRIBUTIONS

All authors have read and approved the final manuscript.

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Not applicable.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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