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Legal Reform in Space: Navigating the Future of Cosmic Mining Regulations

Yaries Mahardika Putro [a] ✉, **Muhammad Insan Tarigan** [a], **Haekal Al Asyari** [b]

[a] Faculty of Law, University of Surabaya, Indonesia
[b] Marton Géza Doctoral School of Legal Studies, University of Debrecen, Hungary

✉ corresponding email: yariesmp@staff.ubaya.ac.id

Abstract

The rapid advancement of space technology and the increasing demand for natural resources have heightened interest in extraterrestrial resource extraction, particularly Helium-3 from the Moon. However, space mining is contentious in international law, as only a few nations currently have the capability to extract these resources. This raises concerns among emerging space actors, like Indonesia, about equitable benefit-sharing as outlined in the Outer Space Treaty (OST). The Moon Agreement aimed to create a legal framework for lunar resource utilization, but its effectiveness is limited due to the lack of ratification by major spacefaring nations. This situation has sparked international debate on whether current space law adequately governs space mining or if legal reform is needed to ensure fair access and sustainable development. The absence of a universally recognized regulatory regime, akin to the seabed mining framework under the United Nations Convention on the Law of the Sea (UNCLOS), complicates the issue further. This paper uses a normative juridical method to explore the legal challenges of space mining, especially from the perspective of emerging space actors. Without a

comprehensive regulatory framework, unchecked exploitation of lunar resources could lead to severe environmental consequences and exacerbate disparities in access to space resources. Legal reforms are necessary to promote sustainability and equitable participation, limiting the dominance of spacefaring nations and protecting the rights of emerging space actors in the expanding space economy.

Keywords

Cosmos Mining, Emerging Space Actors, Environmental Protection, Fair and Equitable Sharing of Benefits.

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Introduction

The evolution of space exploration has progressed through several distinct historical phases, each marked by specific technological and geopolitical characteristics. The initial phase, known as the "Proto-space Age," began before World War II and focused primarily on advancements in rocketry and astronautics, largely pioneered by visionary scientists such as Robert H. Goddard, Hermann Oberth, and Konstantin Tsiolkovsky.[1] What was once the realm of speculation and imagination gradually transitioned into a reality where states aimed to project their technological presence beyond Earth's atmosphere.

The era widely referred to as "Space Exploration 1.0" emerged during the Cold War (1950s–1980s), dominated by strategic competition between the United States and the Soviet Union.[2] This period saw historic achievements such as the 1957 launch of Sputnik, [3] , Yuri Gagarin's orbital flight in 1961,[4] and the Apollo 11 Moon landing in 1969. [5] Despite the prevailing geopolitical rivalry, cooperation within political blocs also materialized, showcasing both national prestige and growing technological prowess.[6] The placement of satellites into orbit became a hallmark of this period, with over 1,500 satellites launched for a wide range of civilian and military purposes. Approximately 40% of

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1 Nicolas Peter, "Towards a New Inspiring Era of Collaborative Space Exploration," in Humans in Outer Space - Interdisciplinary Odysseys, ed. Luca Codignola and Kau-Uwe Schrogly (Wien: Springer, 2009), 107–18.

2 Peter.

3 Peter Jankowitsch, "The Background and History of Space Law," in Handbook of Space Law, ed. Frans von der Dunk and Fabio Tronchetti (Cheltenham: Edward Elgar Publishing Ltd., 2015), 1–28, https://doi.org/10.4337/9781781000366.

4 Elya Taichman, "The Artemis Accords: Employing Space Diplomacy to De-Escalate a National Security Threat and Promote Space Commercialization," American University Security Law Brief 11, no. 2 (2021): 111–46, https://www.cfr.org/backgrounder/space-exploration-and-us-competitiveness.

5 Frans Von der Dunk, "Legal Aspects of Private Manned Spaceflights," in Handbook of Space Law, ed. Frans von der Dunk and Fabio Tronchetti (Cheltenham: Edward Elgar Publishing Ltd., 2015), 662–716, https://doi.org/10.4337/9781781000366.

6 Nicolas Peter, "The Changing Geopolitics of Space Activities," Space Policy 22, no. 2 (May 2006): 100–109, https://doi.org/10.1016/j.spacepol.2006.02.007.

these satellites were operated by the United States, followed by China (13%), Russia (10%), and several other countries.[7]

Following the Cold War, the orientation of space activities shifted significantly. From 1991 to 2015, the "Space Exploration 2.0" phase was characterized by international collaboration and the rise of new players beyond the two Cold War superpowers. Institutions such as the European Space Agency (ESA) and other national space agencies emerged as significant actors.[8] This stage began in 1991 and ended in 2015. This period was marked by increased bilateral and multilateral cooperation, as well as a diversification of actors, including private entities.[9] During this era, the role of governments in space activities was no Space-based technologies such as telecommunications, weather monitoring, remote sensing, GPS, and satellite broadcasting became part of daily life, signaling a shift from government-led space projects to market-driven applications.[10] The driving forces behind space missions were no longer being shaped mainly by political agendas or demonstrations of technological superiority, but were increasingly being influenced by economic interests. This development was followed by the emergence of "Space Exploration 3.0," in which long-term strategies are expected to be increasingly driven by commercial potential. Moreover, academic institutions and other public organizations have also been identified as new contributors to this evolving phase. [11]

Entering the "Space Exploration 3.0" era, space has increasingly been viewed through a commercial and strategic lens. The focus expanded to long-term missions targeting the Moon, Mars, and other celestial bodies, with an emphasis on expanding human economic activity beyond Earth. This phase introduced new actors, private companies, academic institutions, and public organizations, into the domain of space exploration. One of the most ambitious aspects of this

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7 George Barakos and Helmut Mischo, "Space Mining Is the Industry of the Future ... or Maybe the Present?," Moon Mining, February 2020, https://www.researchgate.net/publication/339627406.

8 Peter, "The Changing Geopolitics of Space Activities."

9 Peter, "Towards a New Inspiring Era of Collaborative Space Exploration."

10 Ricky Lee, Law and Regulation of Commercial Mining of Minerals in Outer Space (Heidelberg: Springer, 2012), http://www.springer.com/series/6573.

11 Lee.

development is the utilization of space resources, particularly through In-Situ Resource Utilization (ISRU). [12] This approach seeks to reduce the need for transporting supplies from Earth by using materials available in space, thus lowering operational costs and risks.

The rapid advancement of space technology and the growing interest in cosmic mining demand an urgent legal reform to ensure clarity, fairness, and sustainability. Existing international space law remains ambiguous regarding resource extraction, creating potential conflicts among states and private entities. The evolving principles of space governance must balance economic interests with the notion of space as a domain for all humankind, preventing monopolization by a few powerful actors. Additionally, the societal implications of space resource utilization require regulations that promote equitable access and prevent exploitation that mirrors historical patterns of resource control on Earth. Without a comprehensive legal framework, the future of space mining risks being shaped by legal uncertainty, geopolitical tensions, and ethical dilemmas that could hinder long-term, responsible space exploration.[13]

Human civilization is currently entering a transformative phase in the use and exploration of outer space, particularly in the field of extraterrestrial resource extraction. Activities such as space mining, targeting the Moon, near-Earth asteroids (NEAs), and even Mars are no longer speculative but increasingly part of concrete governmental and commercial agendas.[14] This growing interest is largely driven by the mounting scarcity of essential raw materials on Earth, alongside a continuous rise in global population and industrial demand. Both private enterprises and national space agencies have begun to consider outer space as a viable frontier to secure access to strategic resources. Celestial

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[12] Georgios Kyriakopulos, "Legal Regimes for a Sustainable Space Resource Utilization" (Vienna, 2018).

[13] Evie Kendal, "Asteroid Mining vs the Carbon Bubble: Ethical Considerations for Space Resource Extraction," *Accounting, Auditing & Accountability Journal* 37, no. 5 (May 2, 2024): 1345–75, https://doi.org/10.1108/AAAJ-12-2022-6186.

[14] Jack Adam Lampkin and Bill W. McClanahan, "Astronomical Withdrawals: A Green Criminological Examination of Extreme Energy Mining on Extraterrestrial Objects," *Crime, Law and Social Change* 81, no. 4 (May 2024): 365–84, https://doi.org/10.1007/s10611-023-10123-9.

bodies within our Solar System, including the Moon and numerous asteroids, are known to contain vast deposits of valuable elements, minerals, and hydrocarbons. Some of these materials are rare or declining on Earth, making them attractive for long-term sustainability. [15] The majority of asteroids are located within the Main Asteroid Belt between Mars and Jupiter. Among these, a particular class of asteroids—those with orbits that intersect or approach Earth's path are classified as Near-Earth Asteroids (NEAs). [16] Within the NEA category, subgroups such as the Apollos, Amors, and Atens have been identified as promising targets for potential mining operations, especially in anticipation of terrestrial resource depletion.[17] These asteroids are believed to host a variety of industrially significant materials, including ferrous metals, cement-forming compounds, phosphates, nitrogen, sulfur, and metal sulfides. [18] According to estimates by NASA, the collective value of resources contained within these NEAs could reach as high as US$700 quintillion, an amount theoretically equivalent to US$95 billion for every person on Earth.[19]

The NASA initiated the OSIRIS-REx mission in 2016 with the objective of exploring the asteroid Bennu and procuring samples to be brought back to Earth [20]. China accomplished a significant milestone in space exploration by landing the Chang'e-4 and Yutu-2 on the Moon's

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15 Jonathan R Tate, "Near Earth Objects-a Threat and an Opportunity," Physics Education 38, no. 3 (2003): 218–23, www.iop.org/journals/physed.

16 A Morbidelli et al., "Origin and Evolution of Near-Earth Objects," in Asteroids III, ed. William F. Bottke et al. (Arizona: The University of Arizona Space Science, 2002), 409–22.

17 Charles T. Kowal and John E. Gaustad, "Asteroids: Their Nature and Utilization," American Journal of Physics 57, no. 9 (September 1989): 861–62, https://doi.org/10.1119/1.15887.

18 John S.' 'Lewis, Asteroid Mining 101: Wealth for the New Space Economy (California: Deep Space Industries, 2015).

19 Senjuti Mallick and Rajeswari Pillai, An Examination of the Potential of Space Mining and Its Legal Implications (New Delhi: Observer Research Foundation, 2019).

20 Fengna Xu, "The Approach to Sustainable Space Mining: Issues, Challenges, and Solutions," in IOP Conference Series: Materials Science and Engineering, vol. 738 (Institute of Physics Publishing, 2020), https://doi.org/10.1088/1757-899X/738/1/012014.

far side on January 3, 2019. [21]. Parallel to such state-led missions, several private entities [22], such as Planetary Resources Inc., Deep Space Industries, and Moon Express have declared intentions to extract natural resources from outer space. [23]. While the legality of such activities remains partially unsettled, an emerging interpretation among spacefaring nations suggests that commercial resource utilization is not inherently incompatible with current international space law.

Although widely regarded as the cornerstone of international space governance, the 1967 Outer Space Treaty (OST) offers limited clarity on the permissibility of extracting resources from celestial bodies.[24] The Treaty articulates overarching principles such as the demilitarization of outer space, the promotion of global cooperation, and equitable benefit-sharing but remains silent on the specific matter of commercial space mining. Article I affirms the right of all nations to explore and use outer space, yet it leaves unresolved whether this right extends to private sector activities involving material extraction. Compounding the ambiguity, Article II forbids national appropriation of outer space or celestial bodies by any means, without specifying whether the removal of natural resources constitutes such appropriation. Additionally, Article VIII introduces further legal complexity by assigning jurisdiction and authority to states over space objects they have registered, as well as over personnel operating within them. [25]

This creates a scenario in which states can exert legal authority over space missions without necessarily claiming sovereignty over the celestial bodies involved. Consequently, interpretations of these provisions vary widely. Some legal scholars argue that space mining is permissible as long as there is no territorial claim, while others believe that extracting and

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[21] Xu.

[22] Tanja Masson-Zwaan and Neta Palkovitz, "Regulation of Space Resource Rights: Meeting the Needs of States and Private Parties," Questions of International Law 35 (2017): 5–18, www.spaceresources.public.lu/en/did-you-know/index.html.

[23] Stella Tkatchova, Emerging Space Markets (Berlin: Springer, 2018), http://www.springer.com/series/6575.

[24] United Nations, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies," January 27, 1967.

[25] Nations.

profiting from extraterrestrial resources violates the spirit, if not the letter, of the non-appropriation principle. In the absence of definitive legal language, the permissibility of space mining remains unsettled and continues to be debated in academic, diplomatic, and policy-making circles. This ambiguity has contributed to a fragmented legal environment, where national laws attempt to fill the gap left by international instruments that have yet to adapt to the realities of commercial space activity.[26]

Compared to the Outer Space Treaty, the 1979 Moon Agreement adopts a more restrictive legal stance on space resource utilization. Articles 11(3) and 11(5) prohibit ownership of lunar resources by any state, entity, or individual, and require that their exploitation be subject to an international regime yet to be established. Accordingly, state parties must first conclude such an arrangement before engaging in commercial extraction.[27] In light of ongoing legal uncertainty and the lack of a binding multilateral framework, non-party states to the Moon Agreement such as the United States and Luxembourg have enacted domestic legislation to authorize and regulate space resource activities under national law.[28] Similarly, the United Arab Emirates [29] and Japan [30] have enacted municipal laws to regulate and support commercial space resource utilization under their respective jurisdiction.

It is evident that space mining holds significant advantages for future generations. In addition to offering access to critical raw materials and valuable mineral resources, the utilization of space resources is also regarded as a driving force behind the emergence of a new space economy. Through this development, long-term contributions are

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[26] International Institute of Space Law, "Position Paper on Space Resource Mining" (International Institute of Space Law, December 20, 2015), www.iislweb.org.

[27] Masson-Zwaan and Palkovitz, "Regulation of Space Resource Rights: Meeting the Needs of States and Private Parties."

[28] Scot W. Anderson, Korey Christensen, and Julia Lamanna, "The Development of Natural Resources in Outer Space," Journal of Energy and Natural Resources Law 37, no. 2 (April 3, 2019): 227–58, https://doi.org/10.1080/02646811.2018.1507343.

[29] Sarwat Nasir, "UAE's National Space Law Comes into Effect," The National News, February 24, 2020, https://www.thenationalnews.com/uae/science/uae-s-national-space-law-comes-into-effect-1.983817.

[30] Jeff Foust, "Japan Passes Space Resources Law," Space News, June 17, 2021.

expected to be made toward the social and economic advancement of future generations.[31] Additionally, the Moon is rich in mineral resources that can be refined similarly to Earth's current methods. Lunar soil holds other valuable resources such as helium-3, rare soil elements, and vast quantities of ice water [32]. However, the existence of these potentials in outer space may lead to conflicts among countries, particularly between developed and developing nations or, in other words, between established spacefaring nations and emerging space actors (EMSAs).

The space activities not only belong to space power and spacefaring nations but also other nations such EMSAs. The facts that space resource utilization activities mostly done by the space power and spacefaring nations. Indeed, it influenced by their space policy and advancement of space technology that capable to mine in outer space. Therefore, it is crucial to emphasize the sharing of benefits principle to this activities. As province of all mankind, space should guarantee the fair and equal access for developing countries. In other words, the space power and spacefaring nations has legal obligation to implementing equitable sharing of benefits to the emerging space actors, either through sharing of knowledge or technology in mutual cooperation. In other side, the increasing interest of space actors in the Moon and other Celestial Bodies for multipurpose activities other than scientific investigation, it is worth to emphasize the environmental protection during the activities. For example, the growing number of actors engaging in lunar activities has raised concerns that the environmental challenges experienced in Earth's orbit, such as the proliferation of space debris could potentially be replicated in the lunar environment. Moreover, lunar dust, which may be dispersed as a result of surface operations, is regarded as a significant potential hazard that could pose serious environmental and operational risks.[33]

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[31] Barakos and Mischo, "Space Mining Is the Industry of the Future ... or Maybe the Present?"

[32] Robert Shishko et al., "An Integrated Economics Model for ISRU in Support of a Mars Colony--Initial Status Report" (American Institute of Aeronautics and Astronautics (AIAA), 2015), https://doi.org/10.2514/6.2015-4564.

[33] Thomas Cheney et al., "Planetary Protection in the New Space Era: Science and Governance," Frontiers in Astronomy and Space Sciences 7 (November 13, 2020), https://doi.org/10.3389/fspas.2020.589817.

The rapid advancement of space mining has sparked intensified global discourse regarding the capacity of existing international legal frameworks to govern such activities effectively. A central issue is whether the legal principles outlined in treaties like the 1967 Outer Space Treaty (OST) are capable of addressing new legal and operational complexities, or whether a more robust legal reform is necessary. While the OST affirms that outer space exploration must benefit all nations regardless of their developmental status, it does not elaborate on mechanisms for enforcing this ideal in practice.

The 1979 Moon Agreement characterizes lunar resources as the common heritage of humankind and envisions an international regulatory framework. However, its legal impact is limited due to low ratification, particularly by major space powers. Ongoing divisions between developed and developing states regarding equitable benefit-sharing have further impeded its enforcement. In response to the absence of a binding global regime, states such as the United States, Luxembourg, and the UAE have adopted national laws permitting private space resource activities. These measures, some of which recognize proprietary rights have raised legal concerns over potential inconsistencies with Article II of the Outer Space Treaty, thereby contributing to normative fragmentation. This imbalance underscores the urgency for a unified and enforceable legal framework that ensures the sustainable and equitable governance of space activities. Without such a regime, there is a risk that dominant space actors will continue to shape the legal landscape unilaterally, potentially to the detriment of emerging space nations.

Therefore, the needs to strengthening the equitable of sharing benefits and environmental protection on space mining by spacefaring nations is necessary. As one of the emerging space actors which a long history in space activities [34], Indonesia may led to persuade other emerging space actors to encourage the space miner to conform their activities to those two provisions. Therefore, it is crucial to develop a legal framework which not only could guarantee equal access regarding space resources but also could protect the rights of all countries to get the benefit of celestial bodies.

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[34] Robert C Harding, Space Policy in Developing Countries (Abingdon: Routledge, 2013).

Indeed, there have been numerous studies on equitable sharing of benefits and environmental protection in space mining activities. First, Shannon Suryaatmadja, et.al [35] discuss Indonesia's preparedness for space mining, focusing on domestic legal gaps and the country's need to update its space legislation. While overlapping in national context, your article extends the discussion from domestic readiness to Indonesia's potential international role, promoting the development of a multilateral regulatory regime that centers on sustainability and fairness. The uniqueness in our study lied on its broader geopolitical and normative ambition—it is not merely about legal harmonization but about mobilizing EMSAs into a collective voice for new international norms and institutions.

Subsequently, Regi Rivaldi [36] critiques the Artemis Accords for their reinterpretation of Article II of the OST and potential to reshape customary international law in favor of spacefaring powers. His analysis is rooted in legal doctrine and sovereignty debates. While both articles share a concern about normative fragmentation and power imbalances, this research expands the scope by embedding the discussion within Indonesia's legal and geopolitical context. The novelty lies in emphasizing not just doctrinal critique but the strategic diplomatic role EMSAs like Indonesia could play in shaping new regulatory pathways and resisting the de facto legal dominance of bilateral or exclusive arrangements.

Third, Claudia Cinelli and Katarzyna Pogorzelska [37] focus on the lack of environmental safeguards in space law and propose integrating principles from international environmental law, particularly the precautionary principle. This aligns with the sustainability theme in your

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[35] Shannon Suryaatmadja, Vicia Sacharissa, and Konrardus Elias Liat Tedemaking, "The Space Rush: Reviewing Indonesia's Space Law in Facing the Rise of Space Mining," Hasanuddin Law Review 6, no. 2 (August 11, 2020): 125, https://doi.org/10.20956/halrev.v6i2.2174.

[36] Regi Rivaldi, "THE ARTEMIS ACCORDS AND PROPERTY RIGHTS IN OUTER SPACE," Journal of Law and Policy Transformation 7, no. 2 (December 31, 2022): 36, https://doi.org/10.37253/jlpt.v7i2.7236.

[37] Claudia Cinelli and Katarzyna Pogorzelska, "The Current International Legal Setting for the Protection of the Outer Space Environment: The Precautionary Principle Avant La Lettre," Review of European Community & International Environmental Law 22, no. 2 (2013), http://celestrak.com/satcat/boxscore.asp.

study. However, while they prioritize space debris and environmental hazards, this article combines environmental concern with distributive justice—framing space mining not only as an ecological risk but also as a potential source of geopolitical inequality. The significance of this work lies in merging environmental protection with socio-legal equity, a dimension often missing in purely technical or ecological discussions.

Furthermore, Jinyuan Su [38]article argues that unilateral space resource exploitation is not inherently prohibited under current international law, provided that activities adhere to the principles of non-exclusion and do not exacerbate inequality. While Su underlines the legal vacuum and calls for an international regulatory regime, his focus centers on legality and general governance mechanisms. In contrast, this study adds urgency by highlighting how such legal ambiguity could marginalize emerging space actors like Indonesia, especially if the current laissez-faire trend continues. It stresses the pressing need for reforms that incorporate benefit-sharing and environmental safeguards, issues that Su touches on but does not frame through the specific vulnerabilities of EMSAs.

Lastly, John G. Wrench [39] article presents a liberal interpretation of the Outer Space Treaty, asserting that the principle of non-appropriation does not bar resource extraction, drawing parallels to other international regimes like UNCLOS and the Antarctic Treaty System. His legal optimism is grounded in a belief that flexible interpretation allows room for responsible mining. However, this article counters Wrench's assumption by presenting the perspective of EMSAs that face systemic exclusion in such interpretations. The research positions itself as a critical response, calling attention to how such legal leniency could institutionalize inequity and environmental risk, thus making the case for the urgency of reform with EMSAs as active stakeholders, not passive observers.

Nevertheless, uses the point of view from emerging space actors in examining the importance of equitable sharing of benefits and

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[38] Jinyuan Su, "Legality of Unilateral Exploitation of Space Resources under International Law," International and Comparative Law Quarterly 66, no. 4 (October 1, 2017): 991–1008, https://doi.org/10.1017/S0020589317000367.

[39] John G Wrench, "Non-Appropriation, No Problem: The Outer Space Treaty Is Ready for Asteroid Mining," Case Western Reserve Journal of International Law 51, no. 1 (2019): 437–62.

environmental protection in space mining activities would be the novelty of this study. In addition, this study also argue that it is necessary for the Indonesian government to persuade other emerging space actors to established international regime on the extra-terrestrial mining based on the value of the long-term sustainability of outer space. At the end, this study aims to identify the classification of space power countries and to examine the problems of extra-terrestrial mining and challenges of extra-terrestrial mining for emerging space actors.

The study employed normative juridical research. The purpose of this method is to find solutions to legal issues and the problems that arise in it. The results to be achieved later give prescriptions about what should be on legal issues that submitted. This legal research is carried out through a conceptual approach. This research identify the classification of space power and to the problems of space mining and challenges of space mining by the emerging space actors.

A. The Classification of Space Power

In his writings, Carl Sagan remarked that governments rarely allocate substantial budgets solely for scientific discovery or exploratory purposes; rather, such investments must serve strategic and political interests.[40] This observation challenges the common perception that space initiatives are primarily motivated by peaceful exploration and international collaboration. Historical trends suggest otherwise—many leading spacefaring nations have pursued space programs with embedded national security agendas, even while engaging in cooperative, non-military projects. [41] This underscores the idea that state power is no longer confined to terrestrial domains such as land, sea, and air, but has expanded into outer space as a new frontier of geopolitical influence. Although there is no universally accepted definition of what constitutes "space power," several scholars have offered interpretations to conceptualize it.

One such contribution came from David Lupton in 1998, who described space power as a nation's ability to effectively use the space

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[40] Carl Sagan, Pale Blue Dot : A Vision of the Human Future in Space (New York: Ballantine Books Edition, 1997).

[41] Harding, Space Policy in Developing Countries.

environment to achieve its political, economic, or strategic goals, supported by a broad range of astronautical capabilities. According to Lupton, a nation reaches the status of a space power once it demonstrates mastery in utilizing space across multiple dimensions. [42] These include satellite technology, space exploration, planetary research, and other applications, along with enabling factors such as military preparedness, industrial resilience, and diplomatic leverage. [43]. Consequently, becoming a space power entails more than just technological capability, it requires comprehensive integration of space assets into a nation's broader strategic framework.[44]

On the other hand, RAND research offered their notion of space power as a means of achieving national goals through space medium and space capabilities [45]. However, the program's main aim, although having a broad and generic nature, is to employ space as a medium separate from land, sea and air and to use space-related capacities. The concepts of space power are also strengthened by these two definitions rather than the military side of the domain; they also strengthen the business and political components of space that work together to accomplish specific national objectives [46].

In 2019, the European Space Policy Institute (ESPI) published a report analyzing the global landscape of space actors by evaluating their comparative strength and positioning in terms of "space power." [47] This analysis introduced a classification system built around two principal

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[42] David E Lupton, ON SPACE WARFARE: A Space Power Doctrine (Alabama: Air University Press, 1998).

[43] Marco Aliberti, Matteo Cappella, and Tomas Hrozensky, Measuring Space Power A Theoretical and Empirical Investigation on Europe (Vienna: Springer, 2019), http://www.springer.com/series/15974.

[44] Aliberti, Cappella, and Hrozensky.

[45] Dana J. Johnson, Scott Pace, and C. Bryan Gabbard, Space Emerging Options for National Power (Washington: RAND, 1998).

[46] LTC Brad Townsend, "Space Power and the Foundations of an Independent Space Force," AIR & SPACE POWER JOURNAL 33, no. 4 (2019): 11–24.

[47] Aliberti, Cappella, and Hrozensky, Measuring Space Power A Theoretical and Empirical Investigation on Europe.

dimensions: capacity and autonomy.[48] The concept of capacity reflects a nation's ability to implement space-related strategies effectively in support of political, economic, or societal goals. It comprises both *hard capacity*, such as the technical means to conduct satellite launches or operate missions and *soft capacity*, which includes integrating space services into broader national frameworks, infrastructure, and governance. Meanwhile, autonomy is defined as a country's ability to shape and pursue its own space agenda independently, regardless of outside pressures. This autonomy is further divided into *technical autonomy*, referring to the domestic capability to access and operate in space, and *political autonomy*, which pertains to the freedom to set national space policy without external dependence.[49]

States that demonstrate high levels of both capacity and autonomy are designated as space powers, nations capable of independently executing and benefiting from space activities to serve their national interests. Conversely, limited space nations are those with minimal technological and institutional readiness. Between these two ends of the spectrum lie spacefaring nations, whose capacity and autonomy vary depending on their developmental trajectory and political will. According to the ESPI classification, the United States, China, and Russia qualify as current space powers. [50] Countries such as Japan and India, while not yet at the same level, are categorized as spacefaring nations actively working to expand their capabilities and reduce external dependencies. Notably, China's rapid ascent from spacefaring status to full space power within just two decades illustrates how determined national investment can reshape global standings. In the current geopolitical context, a growing number of countries are evolving from restricted or peripheral roles into more substantial players, recognized as emerging spacefaring nations. These states are steadily building up autonomous capacity, participating in diverse space activities, and

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[48] European Space Policy Institute, "Emerging Spacefaring Nations Review of Selected Countries and Considerations for Europe" (Vienna: European Space Policy Institute, June 21, 2021), www.espi.or.at.

[49] Policy Institute.

[50] Policy Institute.

integrating space into their national priorities with the long-term ambition of joining the ranks of global space powers. [51]

Indeed, the requirements of a so called emerging space actors are different with previous classifications. As explain by the ESPI, The emerging space actors marked by important milestone such as [52]:

a. Implementing a space policy and legal framework for space activities.
b. Creating a dedicated national space institution.
c. Forming a well-funded national space program covering various projects.
d. Procuring space capabilities from other countries for national use.
e. Establishing domestic industrial capabilities for space system development and operation.
f. Building systems and facilities to enable space access.
g. Engaging in international programs and space diplomacy.

Argentina, Brazil, Mexico, South Africa, Egypt, Saudi Arabia, Iran, the United Arab Emirates, Turkey, Australia, New Zealand, Indonesia, Vietnam, Malaysia, and South Korea have been recognized as emerging actors in the domain of space activities. In an effort to provide a structured classification of such states, Harding has proposed a typology that categorizes emerging spacefaring nations into three distinct tiers, based on their technical capacity and institutional readiness to initiate and execute space-related initiatives. States placed within the first tier are characterized by their ability to autonomously develop space technologies, operate indigenous launch capabilities for both orbital and geostationary satellites, and maintain national space agencies. The development of their space programs is typically rooted in earlier advancements in ballistic missile technology or nuclear research programs.[53]. Brazil and India are often cited as examples of first-tier spacefaring nations.[54]

Second-tier countries are described as those possessing limited domestic capacity to produce space technologies, supported by basic launch infrastructure. These states also maintain national space agencies

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51 Policy Institute.
52 Policy Institute.
53 Harding, Space Policy in Developing Countries.
54 Harding.

but are often compelled to engage in cooperative arrangements with technologically advanced space powers to meet their development objectives. Based on these criteria, Iran and South Africa are generally classified as second-tier actors.

Third-tier nations are those whose contributions to space technology remain occasional and largely dependent on external partnerships. These states tend to procure space-related technologies from more advanced providers and frequently enter into cooperative agreements with established space powers to realize their policy goals in the space sector. Countries such as Argentina, Mexico, Egypt, Indonesia, Vietnam, and Malaysia have been identified as falling within this third-tier category[55].

B. The Inadequacy Regulations for Cosmos Mining

The legal framework governing activities in outer space is primarily anchored in the 1967 Outer Space Treaty (OST) and a set of four supplementary agreements. These instruments, while groundbreaking for their time, established only general principles, such as the demilitarization of space and the prohibition of sovereignty claims, without offering sufficient guidance on modern issues like the commercial exploitation of extraterrestrial resources. Consequently, the regulation of activities such as asteroid and lunar mining remains vague and inconsistent under international law.

The OST, often cited as the foundation of space law, enshrines the principle that outer space is a global commons, reflecting the doctrine of *res communis*. [56] Article I grants all states the freedom to explore and utilize space in accordance with international law and in the interest of all humankind. [57] However, it does not explicitly address whether this freedom encompasses the commercial extraction of resources. Article II further complicates matters by prohibiting national appropriation of outer space or celestial bodies, but remains silent on whether acquiring

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[55] Harding.

[56] Nations, "Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies."

[57] Nations.

resources constitutes a form of appropriation. This legal gap has resulted in divergent interpretations.[58]

In contrast, the 1979 Moon Agreement sought to introduce more concrete rules, declaring that the Moon and its natural resources are the common heritage of mankind. Articles 11(3) and 11(5) require the establishment of an international regime prior to the commencement of commercial exploitation. However, the effectiveness of this treaty is undermined by its limited ratification, especially by major spacefaring nations.[59] In response, countries such as the United States, Luxembourg, Japan, and the United Arab Emirates have enacted domestic laws allowing private entities to conduct resource extraction under national authorization. For instance, Luxembourg's Law of July 20, 2017, declares that space resources are capable of being owned. Similarly, the U.S. Commercial Space Launch Competitiveness Act of 2015 provides that American citizens engaged in commercial space resource recovery may possess, own, and sell such resources in accordance with U.S. law and international obligations. These unilateral legislative measures reflect a growing willingness by states to fill the regulatory void left by international law, though they raise concerns about consistency with the OST, particularly Article II's prohibition of appropriation. Scholars such as Frans von der Dunk have pointed out that while the OST restricts state appropriation, it does not explicitly prohibit private actors from exploiting space resources. This ambiguity has triggered legal debates, with some arguing that resource extraction, when not accompanied by territorial claims, does not contravene the OST. Others contend that such activities violate the spirit of the treaty and risk undermining its foundational principles.[60]

The international community has reacted negatively to these unilateral measures. Using a strict interpretation of the OST, there is probably opportunity to argue that space mining might be lawful, as opposed to the Moon Agreement, which outright prohibits it.

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[58] Nations.

[59] United Nations, "Agreement Governing the Activities of States on the Moon and Other Celestial Bodies," December 18, 1979.

[60] Mark Kaufman, "Luxembourg's Asteroid Mining Is Legal, Says Space Law Expert," Inverse, February 8, 2017, https://www.inverse.com/article/34935-luxembourg-s-asteroid-mining-is-legal-says-space-law-expert.

Considering the language and intention of the Outer Space Treaty (OST) and its alignment with the Moon Agreement, it is a far-fetched interpretation to argue that "national appropriation" solely pertains to territorial claims rather than resource claims. The inclusion of resource extraction, albeit indirectly, in the OST can be seen as a reasonable and logical aspect. Historically, there has been no acknowledgment of such claims of ownership, and there exists a unanimous consensus that they are illegitimate. [61].

Although the Moon Agreement has not achieved widespread ratification, it has been argued by some scholars that its core principles have acquired the status of customary international law. From this standpoint, the legalization of space mining is viewed as a direct contravention of foundational norms established under international space law [62]. Nonetheless, under the existing legal regime, significant uncertainties remain regarding the permissibility and limitations of conduct in outer space. Numerous legal ambiguities persist, including unresolved issues such as the identification of competent authorities responsible for licensing and regulating asteroid mining activities, and the compatibility of such actions with the prevailing legal framework established by international space law. [63]

Recognizing the inadequacy of existing instruments, the Hague International Space Resources Governance Working Group issued a set of non-binding "Building Blocks" in 2020. These propose a basic structure for future governance, including provisions on the responsibilities of private operators, benefit-sharing, and environmental safeguards. However, as these building blocks are not legally binding, they have yet to provide a definitive solution to the governance vacuum in space resource utilization.

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[61] James E Dunstan, "Mining Outer Space May Be Cool but Is It Legal? - Room: The Space Journal," Room: Space Journal of Asgardia, 2016, https://room.eu.com/article/mining-outer-space-may-be-cool-but-is-it-legal.

[62] Su, "Legality of Unilateral Exploitation of Space Resources under International Law."

[63] John Kelvey, "Asteroid Mining and Space Law: Who Gets to Profit from Outer Space Platinum?," Slate, September 13, 2013, https://slate.com/technology/2014/10/asteroid-mining-and-space-law-who-gets-to-profit-from-outer-space-platinum.html.

A further complication arises from analogies made with the law of the sea. Some proponents of commercial space mining argue that, akin to fishing in the high seas, extracting minerals from celestial bodies should be considered lawful. However, this analogy is flawed: unlike fish, which are renewable, space resources are non-renewable and finite. Moreover, celestial bodies are not functionally comparable to maritime zones governed by the United Nations Convention on the Law of the Sea (UNCLOS). The legal architecture under UNCLOS, particularly Part XI, establishes a structured regime for the management and equitable sharing of deep seabed resources under the authority of the International Seabed Authority (ISA).

In this regard, some experts advocate replicating the ISA model for space mining governance. Under the ISA, resource exploitation must be authorized in advance, and resulting benefits are to be shared equitably among member states. This collective stewardship approach stands in contrast to the emerging trend in space law, where national jurisdictions seek to legitimize resource ownership through domestic legislation.[64] Under this regime, State Parties are required to obtain prior authorization from the ISA before initiating any exploitation activities. Furthermore, the economic benefits generated from such operations are to be distributed in a manner that ensures equitable sharing among all participating states.[65] This approach is consistent with the principles enshrined in the United Nations Convention on the Law of the Sea (UNCLOS), which advocates for collective state stewardship and fair distribution of resources, rather than endorsing unilateral claims of ownership or profit maximization by individual entities. [66]

One of the primary juridical objectives of this research is to critically examine the normative limitations embedded within existing

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[64] Kehong Yang et al., "A Step-by-Step Relinquishment Method for Cobalt-Rich Crusts: A Case Study on Caiqi Guyot, Pacific Ocean," *Marine Georesources & Geotechnology* 40, no. 9 (August 30, 2022): 1139–50, https://doi.org/10.1080/1064119X.2021.1973161.

[65] Michael Lodge, "The International Seabed Authority and Deep Seabed Mining | United Nations," United Nations, 2016, https://www.un.org/en/chronicle/article/international-seabed-authority-and-deep-seabed-mining.

[66] Lodge.

international legal frameworks governing the exploitation of extraterrestrial resources, particularly those enshrined in the Outer Space Treaty (OST) of 1967 and the Moon Agreement of 1979. While the OST affirms outer space as the "province of all mankind" and prohibits national appropriation, it provides no explicit guidance on the legality, scope, or procedural mechanisms of resource extraction. Similarly, although the Moon Agreement attempts to impose a regulatory structure, its limited ratification by major spacefaring nations renders it ineffective.[67] This legal vacuum enables varying interpretations, ranging from permissive to restrictive, regarding commercial mining rights. The juridical aim here is to highlight this ambiguity and argue for the necessity of precise, binding legal instruments that define permissible conduct, delineate the rights and responsibilities of both state and non-state actors, and clarify the status of extracted resources under international law.

However, the underlying principle of the "province of all mankind" is currently facing challenges. Therefore, in order to achieve even the modest benefits offered by the UNCLOS, a similar approach should be adopted.

C. The Challenges of Cosmos Mining for Emerging Space Actors

As it is known that Indonesia is one of the emerging space actors. Considering the characteristics of emerging space actors that are not yet capable of developing space technology and launching spacecraft independently, this has resulted in concerns from emerging space actors that space resources will be exploited by space powers and spacefaring nations in space mining. In addition, historically, the practice of inequitable of sharing benefits has occurred since the beginning of the space race.

During his historic journey, astronaut Neil Armstrong collected lunar rocks and promptly returned them to NASA and claimed as US

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[67] Andrew J. Cannon, "Space Mining: Why We Need a New Treaty and What Might It Look Like," SSRN Scholarly Paper (Rochester, NY: Social Science Research Network, October 14, 2024), https://doi.org/10.2139/ssrn.5079531.

property [68]. On the other side, The Soviet Union also claimed lunar material as state property and even sold some to its citizens [69]. The U.S has 842 lb of lunar stuff [70]. There is no doubt that NASA and the US government own this material and other data collected by US astronauts. NASA explicitly states that "lunar material retrieved from the Moon during the Apollo Program is U.S. government property [71].

Concerns have also been raised regarding the potential adverse effects that large-scale exploitation of space resources may have on the integrity of the space environment. The process of extracting raw materials from asteroids and small celestial bodies is commonly referred to as asteroid mining[72]. Through this method, both minerals and volatile substances may be obtained from asteroids or inactive comets and subsequently utilized either in situ for applications such as the production of construction materials or spacecraft propellant or transported to Earth for terrestrial use. Examples include the extraction of high-value materials such as platinum and cobalt, which can be repurposed for manufacturing solar power satellites or developing space-based habitats. Additionally, ice-derived water may be converted for use in orbital refueling depots, thereby supporting sustained space operations. The in-space utilization of these resources, particularly for producing essential components such as propellant, storage tanks, radiation shielding, and other infrastructure required for large-scale space

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[68] Lunar Planetary Institute, "Lunar - Missions - Apollo 11 Samples," Lunar and Planetary Institute, 2016, https://www.lpi.usra.edu/lunar/missions/apollo/apollo_11/samples/.

[69] Thomas Gangale, "WHO OWNS THE GEOSTATIONARY ORBIT ? By Where Space Begins The Basis of the Equatorial States ' Claim Arguments Based on Astrodynamics Arguments by Analogy A . Arguments by Analogy Not Persuasive D . A . The UN Resolution on the Use of Nuclear Power Sources," 2006.

[70] U. Ro Theodore, J. Kleiman Matthew, and G. Hammerle Kurt, "Patent Infringement in Outer Space in Light of 35 U.S.C 105: Following the White Rabbit Down the Rabbit Loophole," Boston University Journal of Science & Technology Law 17, no. 2 (2011): 33–67.

[71] Paul K Martin, "NASA'S MANAGEMENT OF MOON ROCKS AND OTHER ASTROMATERIALS LOANED FOR RESEARCH, EDUCATION, AND PUBLIC DISPLAY" (Washington D.C: Office of Inspectorate General, December 8, 2011).

[72] Annette Froehlich, Space Resource Utilization: A View from an Emerging Space Faring Nation (Vienna: Springer, 2018), http://www.springer.com/series/8167.

missions, has been acknowledged as a strategy capable of substantially lowering mission costs and reducing overall energy expenditure.

Presently, terrestrial mining remains the primary source of raw materials globally due to the exorbitant expenses associated with space transportation. However, space mining is driven by the increasing scarcity of Earth's resources, especially high-grade ores of various minerals that are deteriorating [73]. This depletion is a result of the escalating consumption of these industrial minerals by developed and emerging economies. Data suggests that Earth's reserves will be depleted within the next 50 to 60 years , necessitating the exploration of space mining options [74].

One of the identified risks associated with asteroid mining is the possibility of unintended asteroid impacts, wherein celestial bodies within the near-Earth object (NEO) region may collide with planetary surfaces, producing observable physical consequences. [75] While the majority of such collisions have involved relatively small asteroids resulting in minimal planetary disruption larger-scale impacts, particularly those involving terrestrial planets like Earth, have been known to produce catastrophic biospheric consequences. Planetary impact structures and craters serve as enduring geological evidence of these high-energy collisions. Notable among such events is the Chicxulub impact, estimated to have occurred approximately 66 million years ago, which has been widely attributed as a primary cause of the Cretaceous-Paleogene mass extinction.[76] Numerous asteroid strikes have been recorded throughout history, some of which have led to fatalities, injuries, and destruction of property, while others have had more localized environmental effects.

The process of asteroid mining itself necessitates the application of substantial thermal energy during resource extraction. This energy, primarily harnessed from solar radiation, contributes to the emission of

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[73] Guiomar Calvo et al., "Decreasing Ore Grades in Global Metallic Mining: A Theoretical Issue or a Global Reality?," Resources 36 (2016): 1–14, https://doi.org/10.3390/resources5040036.

[74] Calvo et al.

[75] John S. Lewis, Mining the Sky: Untold Riches From The Asteroids, Comets, And Planets (New York: Basic Books, 1997).

[76] Lewis.

heat toward adjacent celestial environments. Due to the absence of an atmospheric medium in outer space capable of absorbing or dissipating this heat, the thermal output generated by extraction activities may have measurable impacts on the ambient temperature dynamics of the surrounding space environment. Accordingly, such thermal effects must be taken into account when planning and conducting resource extraction operations in space.

In addition, large-scale mining operations on the lunar surface have been identified as potentially causing irreversible alterations to the Moon's natural terrain.[77] Concerns regarding the environmental consequences of such activities were formally raised as early as 1984 by the Lunar Base Working Group at Los Alamos National Laboratory, highlighting the need for environmental safeguards in future lunar development initiatives.[78] These potential environmental issues were identified as follows: the increase in atmospheric pressure, which could alter atmospheric compositions and affect astronomical observations [79]. It could also lead to an elevation in extremely low radio frequency background noise, thereby impacting satellite communications and the use of the Moon's far side for radio telescopes. Consequently, there is a clear need for environmental assessment and management to determine the appropriate utilization and preservation of space or planetary surfaces. It is imperative to safeguard the unique lunar environment to ensure the integrity of ongoing lunar research operations.[80] Therefore, it is evident that operational mining on the Moon will have a detrimental impact on the ecosystem.

These things make emerging space actors worried about space mining activities. Therefore, the author argues that an emphasis is needed

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[77] Daniel Capper, "What Should We Do with Our Moon?: Ethics and Policy for Establishing International Multiuse Lunar Land Reserves," *Space Policy* 59 (February 1, 2022): 101462, https://doi.org/10.1016/j.spacepol.2021.101462.

[78] Froehlich, Space Resource Utilization: A View from an Emerging Space Faring Nation.

[79] Froehlich.

[80] Kevin M. Hubbard, Linda T. Elkins-Tanton, and Tanja Masson-Zwaan, "A Mining Code for Regulating Lunar Water Ice Mining Activities," *Proceedings of the National Academy of Sciences* 121, no. 52 (December 24, 2024): e2321079121, https://doi.org/10.1073/pnas.2321079121.

on the importance of equitable sharing of benefits and environmental protection in space mining activities. Considering that those who feel the impact directly from space mining are emerging space actors, especially those in the third tier, it requires a commitment from these emerging space actors to jointly voice their opinions on the importance of equitable sharing of benefits and environmental protection in space mining activities. Indonesia is one of the emerging space actors that has a good history of jointly initiating ideas at the international level. The formation of the non-aligned movement and the Bogota declaration initiated by Indonesia are concrete examples of Indonesia's commitment to emphasizing justice in international forums.

Moreover, the Indonesian government has national space legislation that mandates advocating for sustainable issues in space activities while ensuring the preservation of environmental functions, as stipulated in Article 43 (d) of Law No. 21 of 2013 on Space. Furthermore, space mining, which is part of space commercialization, has been generally regulated under Article 37 of Law No. 21 of 2013 on Space. However, based on the abovementioned article, the government is obligated to establish provisions regarding space commercialization, including space mining, through implementing regulations in the form of government regulations.

Up until now, the discussion has focused on active businesses within the space industry, examining the hurdles and prospects they encounter, as well as proposing solutions to overcome these obstacles. While the draft's scope and aim have been defined, it remains in its early stages of development and has not been publicly released. Ideally, this regulatory framework should encompass the entities required to comply with it, taking into account that private companies, including foreign ones, may play a crucial role in driving the advancement of commercial space activities. Indonesia could draw insights from the §51301 of the Space Resource Exploration and Utilization Act, as it offers an all-encompassing approach that involves all relevant stakeholders [81].

Considering that the strategic position that possessed by the Indonesian government, therefore, at least there are two things that Indonesia can do to ensure space sustainability, namely through space

[81] Suryaatmadja, Sacharissa, and Tedemaking, "The Space Rush."

diplomacy and bringing up the issue of the importance of formulating new international legal instruments related to space mining activities before the UNCOPUOUS.

D. Long Term Sustainability as a Solution for Cosmos Mining

The current trajectory of space mining activities—dominated by technologically advanced nations and private entities—risks reproducing global patterns of inequality, where emerging space actors (EMSAs) remain peripheral in both decision-making processes and benefit-sharing mechanisms. This study seeks to promote a sustainable governance model that reflects social justice by advocating for a system where access to space resources is not determined solely by technological superiority or economic power, but by a shared commitment to fairness, mutual cooperation, and long-term planetary stewardship. The inclusion of EMSAs like Indonesia in international forums and regulatory processes is essential not only for equitable development but also for cultivating a space governance regime that is socially cohesive and globally representative.

Furthermore, the sociological dimension of long-term sustainability involves recognizing how societal structures, public perception, and cultural narratives influence the legitimacy and success of space mining governance. As space activities expand beyond the scientific elite and become increasingly commercialized, it is crucial to bridge the gap between global policy frameworks and grassroots awareness. This article therefore argues that sustainability in space cannot be achieved through legal and technical mechanisms alone; it must also be supported by broad social consensus and public engagement.[82] Encouraging educational initiatives, inclusive dialogue, and civil society participation in space-related policymaking can foster a culture of

[82] Arkady Ursul and Tatiana Ursul, "On the Path to Space Mining and a Cosmic Sustainable Way of Socio-Natural Interaction," *Philosophy and Cosmology* 25, no. 25 (2020): 69–77, https://www.ceeol.com/search/article-detail?id=904955.

accountability and ethical consciousness.[83] In this way, the long-term sustainability of cosmos mining becomes not just an environmental and legal concern, but a sociological commitment to ensuring that outer space remains a domain of collective human progress.

The prospects of outer space mining consist of both economic and technical aspects. This is due to the abundant minerals, hydrocarbons, and other minerals which are otherwise difficult to find on earth.[84] While it is known that exploiting resources on celestial bodies particularly on moon and mars is costly and would require massive amount of investment in time and energy[85], more attention needs to be given on the sustainability aspect of such activity.

The conduct of outer space mining has been characterized as an ultra-hazardous activity, possessing inherent risks capable of causing harm to both the extraterrestrial environment and the Earth.[86] One of the primary concerns is the phenomenon of Earth-originating forward contamination, which has the potential to adversely affect extraterrestrial ecosystems and compromise the scientific integrity of space environments. Such contamination may arise from various sources, including non-hazardous space debris, physically or chemically dangerous hazardous waste, radioactive by-products generated from nuclear-powered space assets, as well as biological materials transported by unmanned probes or human missions. These materials, once introduced into outer space, can pose long-term threats not only to the space environment but also to Earth's ecological balance upon re-entry or unintended dispersal. Accordingly, these forms of contamination are increasingly being viewed as significant obstacles to the sustainable and responsible conduct of space activities, necessitating the development of

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[83] Sergey Krichevsky, "Creation of a 'Cosmic' Human: Ideas, Technologies, Projects, Experience, Risks, Limitations, and Prospects," *Future Human Image* 13, no. 1 (2020): 32–45, https://doi.org/10.29202/fhi/13/4.

[84] Tate, "Near Earth Objects-a Threat and an Opportunity."

[85] Lee, Law and Regulation of Commercial Mining of Minerals in Outer Space.

[86] Su, "Legality of Unilateral Exploitation of Space Resources under International Law."

robust environmental and legal safeguards to preserve the outer space domain for future generations.[87]

However, on the other hand, potential impact of mining activities on the space environment is uncertain and challenging to predict.[88] The concept of sustainable development inherently involves assessing the long-term consequences of human actions and their effects on future generations. Earth serves as a stark reminder of the importance of this perspective, as the present generation grapples with environmental challenges stemming from past decisions. Therefore, it is crucial that mining in outer space considers the well-being of both current and future generations of humans.[89]

When the Outer Space Treaty was established, its primary focus was on promoting the peaceful use of outer space, with little attention given to environmental protection. However, as the prospect of space mining emerges, the interaction between human activities and the space environment becomes increasingly significant.

In this context, the principle of sustainable development offers a valuable framework to balance environmental concerns with development.[90] This principle recognizes the need to protect the environment while pursuing economic gains and technological advancements. Therefore, when States and private entities engage in space mining endeavors, they should consider environmental protection as a fundamental aspect.[91] This entails conducting thorough

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87 Stephen D. Creech, "NASA's Space Launch System: Enabling a New Generation of Lunar Exploration," in 2019 IEEE Aerospace Conference (2019 IEEE Aerospace Conference, Big Sky, MT, USA: IEEE, 2019), 1–11, https://doi.org/10.1109/AERO.2019.8741972.

88 Creech.

89 Nikolaos Iliopoulos and Miguel Esteban, "Sustainable Space Exploration and Its Relevance to the Privatization of Space Ventures," Acta Astronautica 167 (February 2020): 85–92, https://doi.org/10.1016/j.actaastro.2019.09.037.

90 Martin Švec and Nikola Schmidt, "Space Mining: Attempts to Materialize Cosmopolitan Ideas Enshrined in International Space Law," in Governance of Emerging Space Challenges: The Benefits of a Responsible Cosmopolitan State Policy, ed. Nikola Schmidt (Cham: Springer International Publishing, 2022), 133–54, https://doi.org/10.1007/978-3-030-86555-9_8.

91 Gabrielle Leterre, Protecting the Last Frontier: Space Mining and Environmental Sustainability (Kluwer Law International B.V., 2024).

environmental impact assessments and implementing monitoring processes throughout all phases of the mission.[92] The integration of environmental considerations into space mining practices is regarded as essential for ensuring that the exploration and utilization of outer space resources are conducted in accordance with the principle of sustainable development. This principle serves as a normative foundation for promoting responsible and environmentally conscious activities beyond Earth's atmosphere.[93]

In this context, the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS) has formulated the *Guidelines for the Long-Term Sustainability of Outer Space Activities*. These guidelines offer a comprehensive set of recommendations addressing various aspects of space governance, including policy and regulatory frameworks, operational safety, international cooperation, capacity-building and awareness, as well as scientific and technological research. Although intended to assist member states in enhancing the sustainability of their space programs, it must be emphasized that the guidelines are non-binding in nature and do not possess legal force under international law.[94] Given the current absence of a binding international legal regime specifically governing space resource utilization, the establishment of a formal legal framework is of critical importance. Such a framework is necessary to confer legal status upon space mining activities, ensure legal certainty and equitable treatment among stakeholders, and to prevent the emergence of a normative vacuum that could undermine the orderly and sustainable development of outer space.

As time is a relative component of space mining activities, technical obstacles could be overcome with providing the necessary financial

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[92] Dawn L Rothe and Victoria E Collins, "Planetary Geopolitics, Space Weaponization and Environmental Harms," *The British Journal of Criminology* 63, no. 6 (November 1, 2023): 1523–38, https://doi.org/10.1093/bjc/azad003.

[93] Aikaterini Vakaki, "A New Gold Mining Rush?," Journal of Space Law 46 (2022): 421, https://heinonline.org/HOL/Page?handle=hein.journals/jrlsl46&id=433&div=&collection=.

[94] United Nations Office for Outer Space Affairs, Guidelines for the Long-Term Sustainability of Outer Space Activities of the Committee on the Peaceful Uses of Outer Space (United Nations, 2022), https://doi.org/10.18356/9789210021852.

incentives. Legal obstacles on the other hand would be less-negotiable in this context. A commercial space mining project will have to deal with legal difficulties based on the current body of national and international space legislation.[95] Fundamentally, this is since huge financial investments in the technology advancements necessary for such ventures cannot be made in a setting of legal uncertainty. [96]

E. The Urgency for a Regulatory Framework and a Governing Body

In terms of practical solutions, some authors have given proposals to include international collaborations, establishment of an international governing body, creation of intergovernmental environmental regulations, promotion of public participation and a system of equitable benefit sharing.

On a general note, Xu advocates for strengthening the legal regime for space mining by achieving international consensus, like the Antarctic Treaty System.[97] This would involve formulating an environmental code of conduct. Xu proposes promoting international cooperation among states to adhere to sustainability principles. This could be achieved by individually and collectively establishing regulations to share information on space debris and developing transparency and confidence-building measures. Additionally, Xu suggests the implementation of an international tax or license on launch operations to follow the "polluter pays" principle.

Furthermore, Reiman also argues that it is necessary to emphasize the importance of developing a regulatory framework concerning the utilization of natural resources in outer space. Outer space should be regarded as an "environment" rather than a "mere phenomenon," thus

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[95] Rohan Vasanth and Vaishnav S., "Legal Challenges and the Concept of the Commons in Commercial Space Mining: A Need for Uniformity in International Space Law," *International Journal of Law Management & Humanities* 7 Issue 2 (2024): 2703, https://heinonline.org/HOL/Page?handle=hein.journals/ijlmhs28&id=2729&div=&collection=.

[96] Vakaki, "A New Gold Mining Rush?"

[97] Xu, "The Approach to Sustainable Space Mining: Issues, Challenges, and Solutions."

necessitating its protection.[98] However, is outer space truly deserving of protection? This question pertains to environmental ethics in the use and exploitation of outer space, leading to the conclusion that outer space, as an environment, must indeed be protected. Additionally, it should be underscored that the perspective from which outer space is viewed as an environment should be based on ecocentrism rather than anthropocentrism. From an anthropocentric viewpoint, the natural environment has no intrinsic value; its value is measured by human needs. Conversely, from an ecocentric perspective, the environment has intrinsic value that is independent of human needs and is worthy of protection.[99] Therefore, it is crucial to establish regulations concerning the use and exploitation of outer space based on an ecocentric orientation.

In relation to the institution body, Creech proposes an international body like the International Seabed Authority (ISA) to govern mining permits or licenses.[100] Different from the Antarctic Treaty, such body would implement a lease system based on population, granting royalties to lower-income nations. In this context, we agree that the importance of environmental protection by requiring an Environmental Impact Assessment (EIA) for space mining activities, adhering to international environmental law principles is achievable.

Similarly, Lee specified the need for not only a legal framework but also a governing body to implement space mining regulations effectively. He proposes the establishment of "International Space Development Authority." Such organization would have a quasi-legislative body, an administrative secretariat, and a system for granting "exploration permit," "mining permit," and "occupation permit." Lee suggests implementing equitable sharing of benefits from space mining and establishing a judicial mechanism for dispute settlement to address

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[98] Saara Reiman, "Is Space an Environment?," Space Policy 25, no. 2 (May 1, 2009): 81–87, https://doi.org/10.1016/j.spacepol.2009.03.005.

[99] Kevin MacWhorter, "Sustainable Mining: Incentivizing Asteroid Mining in the Name of Environmentalism," William & Mary Environmental Law and Policy Review 40, no. 11 (2016): 645–76, https://scholarship.law.wm.edu/cgi/viewcontent.cgi?article=1653&context=wmelpr.

[100] Creech, "NASA's Space Launch System."

conflicts between applicants, permit-holders, and the Authority.[101]

However, this research challenges the prevailing anthropocentric and utilitarian perspectives that currently underpin the discourse on space mining. The dominant narrative treats outer space primarily as a resource frontier to be exploited for economic gain, often overlooking its intrinsic value and the moral implications of unregulated extraction. This article proposes a paradigm shift toward an ecocentric understanding of outer space—viewing celestial bodies not merely as commodities, but as elements of a shared cosmic environment that deserve ethical consideration and protection. In line with the principle of sustainable development, the philosophical objective is to advocate for a regulatory approach that respects the intergenerational responsibility of humanity to safeguard the cosmic commons, ensuring that today's pursuits do not compromise the opportunities and well-being of future generations.

Furthermore, the research is grounded in the philosophical principle of global justice, especially in addressing the disparities between developed spacefaring nations and emerging space actors (EMSAs). The unequal distribution of technological capabilities and legal influence risks perpetuating a form of neo-colonialism in outer space, where powerful nations shape the rules to their advantage. By calling for a multilateral and inclusive governing body, we promotes a moral commitment to fairness, equity, and solidarity among all nations. The proposed international framework is not just a legal necessity but a philosophical imperative to uphold the foundational ideals of international space law—peaceful use, common heritage, and benefit for all humankind.[102] In this way, it may reinforces that space governance should be anchored not only in legal certainty but also in ethical legitimacy.

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[101] Lee, Law and Regulation of Commercial Mining of Minerals in Outer Space.

[102] Tyler Burdon, "The Final Frontier: A Look at Private Mining Rights in Space," *Houston Business and Tax Law Journal* 24 (2024): 167, https://heinonline.org/HOL/Page?handle=hein.journals/houbtalj24&id=250&div=&collection=.

Conclusion

The development of technology, the increasing number of human population and the decrease in natural resources on Earth encourage countries to find out the existence of space resources. Extra-terrestrial mining as one of the activities of utilizing space resources is encouraged on the basis of the benefits that will be obtained by each party in the future. In order to reduce the burden of financing by the state, the state took the initiative to become investors in companies that wish to take part in this activity. Planetary resources, deep space industries, moon express and Shackleton energy are private companies that have the intention and plan to carry out extra-terrestrial mining activities. However, considering the need for sophisticated technology in these activities, it is very possible that the countries involved in these activities are space power and spacefaring nations. This will certainly raise concerns for emerging space actors such as Indonesia over such exploitation activities. The main concern about this activity is that space sustainability will not be implemented due to the depletion of natural resources in space or the destruction of the surrounding environment. So based on this, it is necessary to emphasize the importance of equitable sharing of benefits and environmental protection so that outer space truly becomes the province of all mankind.

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