

A Doctrinal and Comparative Legal Study of Resource Governance Beyond National Jurisdiction: Deep-Sea Bed, High Seas, Outer Space, and Antarctic Zones

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Abstract

Resources beyond national jurisdiction represent global commons and are regarded as the universal heritage of humankind. However these resources face growing pressures from the economic interests of resource-rich nations. The central objective of this study is to critically analyse how key international treaties and foundational legal principles, particularly the United Nations Convention on the Law of the Sea (UNCLOS), the Outer Space Treaty, and the Antarctic Treaty System (ATS) along with its Environmental Protocol, navigate the complex challenge of managing resource exploitation while ensuring robust environmental protection. The methodology employed for this study is doctrinal, utilizing a comparative analysis of international legal regimes governing resources beyond national jurisdiction, incorporating statutory interpretation, case law review, scholarly discourse, and institutional frameworks, to critically assess regulatory effectiveness, normative principles, and governance challenges across the deep-sea bed, high seas, outer space, and Antarctic regions. The findings of this study underscore that international frameworks are fundamentally designed to promote the sustainable management of global commons. Deep seabed mining activities fall under the regulatory purview of the International Seabed Authority (ISA). The exploration of outer space is guided by the principles enshrined in the Outer Space Treaty, while Antarctica benefits from the comprehensive protective measures of the ATS and its associated Environmental Protocol. Consequently, this study advocates for sustained international cooperation and strict adherence to established legal frameworks to effectively balance resource utilization with the imperative of environmental stewardship, ensuring the preservation of these global commons for the benefit of all humanity.

Keywords: Resources Governance, Global Commons, International Legal Frameworks, Environmental Protection, Comparative Legal Analysis.

1. INTRODUCTION

Resources beyond national jurisdiction consists of the deep-sea bed and high seas, outer space, and Antarctic areas. These Resources present a complex interplay of opportunities for exploration and resource extraction alongside significant challenges for environmental protection and international cooperation.¹ Each of these domains,

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¹ David Freestone, 'Four Treaties in One: The Biodiversity Beyond National Jurisdiction Agreement' (2020) 114(1) American Journal of International Law 1.

lying outside the sovereign control of individual nations, necessitates careful consideration to ensure equitable access, environmental stewardship and long-term sustainability for all humankind.²

The deep-sea bed represents the ocean floor beyond national exclusive economic zones (EEZs) and holds substantial mineral resources. Extracting these resources requires advanced technologies and robust management frameworks to mitigate potential environmental impacts on fragile deep-sea ecosystems.³ The high seas, constituting approximately 64% of the ocean's surface and nearly 95% of its volume,⁴ fall outside the jurisdiction of any single state. This vast expanse, governed by the principles outlined in the United Nations Convention on the Law of the Sea (UNCLOS), presents challenges in terms of resource management, conservation, and the prevention of unregulated activities.

Outer space, commencing at the internationally recognised boundary of the Kármán line, approximately 100 kilometres above Earth's sea level, is a realm of increasing human activity. Beyond its fundamental role in satellite communications, navigation and scientific observation, outer space holds the potential for resource utilisation, including asteroid mining. The absence of a comprehensive international legal regime governing resource extraction in space necessitates proactive discussions and agreements to prevent conflict, ensure equitable access to space resources and promote the peaceful exploration and utilisation of this domain for the benefit of all nations.⁵

The Antarctic is a unique continent dedicated to peace and science under the Antarctic Treaty System (ATS) and exemplifies a successful model of international cooperation for a global common.⁶ The ATS prioritises scientific research, environmental protection and the prohibition of military activities and mineral resource exploitation.⁷ This collaborative framework underscores the potential for international agreements to effectively manage and safeguard regions of global significance.⁸

Underpinning the responsible management of all resources beyond national jurisdiction is the fundamental principle of sustainability. Defined by the Brundtland Commission as 'development that meets the needs of the present without

² Margaret A Young and Andrew Friedman, 'Biodiversity Beyond National Jurisdiction: Regimes and Their Interaction' (2018) 27(3) *Review of European, Comparative & International Environmental Law* 276.

³ Yoshifumi Tanaka, 'Marine Genetic Resources in Areas Beyond National Jurisdiction: Promoting Marine Scientific Research and Equitable Benefit-Sharing' (2019) 34(2) *International Journal of Marine and Coastal Law* 181.

⁴ United Nations Convention on the Law of the Sea (adopted 10 December 1982, entered into force 16 November 1994) 1833 UNTS 3 (UNCLOS).

⁵ 'What Is Space?' (Space.com, 2024) <https://www.space.com/24870-what-is-space.html> accessed 14 May 2025.

⁶ British Antarctic Survey, 'The Antarctic Treaty' (British Antarctic Survey, 2023) <<https://www.bas.ac.uk/about/antarctica/the-antarctic-treaty>> accessed 14 May 2025.

⁷ Ibid.

⁸ Ibid.

compromising the ability of future generations to meet their own needs.⁹ Sustainable management requires a holistic approach that integrates economic, social, and environmental considerations. As articulated in Principle 4 of the 1992 Rio Declaration and acknowledged by the International Court of Justice, achieving sustainable development necessitates reconciling economic progress with environmental protection.¹⁰ This principle of intergenerational equity demands that current resource use does not undermine the ability of future generations to meet their own needs and benefit from these global commons.¹¹

2. DEEP SEABED MINING AND HIGH SEAS (ABNJ)

The area beyond national jurisdiction (ABNJ), encompassing the deep seabed ("the Area") and the high seas, is gaining prominence due to its potential as a source of food, energy, and valuable biological and mineral resources.¹² Beyond these market goods, the oceans in ABNJ provide crucial non-market services vital for Earth's life support systems.¹³ The increasing demand for minerals like cobalt, copper, manganese and nickel, essential for energy transition technologies (e.g., electric vehicle batteries, wind turbine magnets), is driving interest in deep seabed deposits,¹⁴ which some scientists believe are more abundant than terrestrial sources.¹⁵ This technological advancement, enabling exploration of the deepest ocean reaches, has led to the discovery of numerous new species and simultaneously opened the door to commercial exploitation of seabed minerals.¹⁶

Currently, three main resources in the deep seabed and high seas of ABNJ are of commercial interest: manganese nodules (MN) found on abyssal plains,¹⁷ particularly in the Pacific Ocean; seafloor massive sulphides (SMS) located at hydrothermal vents, such as those off Papua New Guinea; and cobalt-rich ferromanganese crusts (CRC) present on seamounts globally, with the largest deposits also in the Pacific.¹⁸ Beyond these metal-rich deposits, methane extraction from gas hydrates in marine sediments on continental slopes and rises, as well as beneath terrestrial permafrost, is also attracting attention.¹⁹ Additionally, commercially valuable resources on the

⁹ *Case Concerning the Gabčíkovo-Nagymaros Project* (Hungary/Slovakia) [1997] ICJ Rep 78 para 140.

¹⁰ Rio Declaration on Environment and Development (adopted 14 June 1992) UN Doc A/CONF.151/26 (Vol I) Annex I (Rio Declaration), Principle 4.

¹¹ *Ibid.*

¹² Global Environment Facility, 'Areas Beyond National Jurisdiction' (GEF, 2023) <<https://www.thegef.org/what-we-do/topics/areas-beyond-national-jurisdiction>> accessed 14 May 2025.

¹³ *Ibid.*

¹⁴ International Seabed Authority, 'Seabed Mining' (ISA, 2023) <<https://www.isa.org.jm/news/isa-releases-landmark-expert-report-highlighting-the-remarkable-contribution-of-isas-global-deep-sea-research-agenda-to-the-un-decade-of-ocean-science-for-sustainable-development/>> accessed 14 May 2025.

¹⁵ *Ibid.*

¹⁶ *Ibid.*

¹⁷ *Ibid.*

¹⁸ US Geological Survey, 'Deep-ocean polymetallic nodules and cobalt-rich ferromanganese crusts: Global ocean new' (USGS, 2023) <<https://www.usgs.gov/publications/deep-ocean-polymetallic-nodules-and-cobalt-rich-ferromanganese-crusts-global-ocean-new>> accessed 14 May 2025.

¹⁹ J-STAGE, 'Methane Hydrate Development' (J-STAGE, 2023) <https://www.jstage.jst.go.jp/article/arr/4/1/4_29/_pdf/-char/en> accessed 14 May 2025.

continental shelf include diamonds, iron sands (rich in titanomagnetite and lime-soda feldspars for steel production), and phosphorites. The fundamental importance of oceans and seas for sustainable development is increasingly recognized.²⁰

2.1 Legal Framework of the ABNJ

The United Nations Convention on the Law of the Sea, 1982 (UNCLOS),²¹ constitutes the principal legal framework governing the deep seabed and the high seas. The International Seabed Authority (ISA), established by the States Parties to UNCLOS, exercises regulatory oversight of mineral-related activities within the Areas Beyond National Jurisdiction (ABNJ). This includes the review of applications for exploration and exploitation submitted by contractors, the assessment of environmental impact assessments and the supervision of mining operations. Entities holding exploration contracts are authorized to prospect for minerals within a designated area of the seabed for a period of fifteen years, with the option of a single five-year extension. Notably, Articles 136, 137.2, and 145 of UNCLOS are of critical importance to deep-sea mining, addressing, respectively, the concept of the common heritage of mankind, the management of resources and the protection of the marine environment. These three articles provides as follows:

2.1.1 Article 136 – Common Heritage of Mankind

This provision declares that ‘the Area (deep-sea bed) and its resources are the common heritage of mankind’.

2.1.2 Article 137.2 – Legal Status of the Area and its Resources

This article clarifies that ‘all rights in the resources of the Area are vested in mankind as a whole, on whose behalf the Authority shall act. These resources are not subject to alienation. The minerals recovered from the Area, however, may only be alienated in accordance with this Part and the rules, regulations and procedures of the Authority.’

2.1.3 Article 145 – Protection of the Marine Environment

This article mandates that ‘necessary measures shall be taken in accordance with this Convention with respect to activities in the Area to ensure effective protection for the marine environment from harmful effects which may arise from such activities.’ To this end, it directs the International Seabed Authority (ISA) to adopt appropriate rules, regulations and procedures for, *inter alia*, the prevention, reduction and control of pollution and other hazards, the avoidance of interference with the ecological balance and the protection of flora and fauna, paying particular attention to activities such as drilling, dredging, excavation, waste disposal and the construction and operation of related infrastructure.

²⁰NOAA Ocean Exploration, 'High Seas Governance' (NOAA, 2023) <<https://www.oceanexplorer.noaa.gov/facts/high-seas-governance.html>> accessed 14 May 2025.

²¹ UNCLOS (n 4).

As of October 2024, the ISA, the body established by UNCLOS States Parties to oversee mineral related activities in the Area Beyond National Jurisdiction (ABNJ), had granted 31 exploration contracts to both public and private mining enterprises for seabed mineral resources.²² Notably, the ISA has yet to reject an application for an exploration contract.²³ While exploitation of the seabed requires ISA's permission, intended to ensure environmental impact monitoring and control, mining activities will inevitably impact the marine environment through habitat removal, sediment plumes, and potential equipment malfunctions. The ISA mandates that contractors collect baseline data and conduct research to assess the long-term consequences of deep-sea mining.²⁴

Although commercial scale deep-sea mining has not yet commenced, exploration contracts for deep-sea resources have been awarded to entities from countries including China, the United Kingdom, Belgium, Germany, France, and Japan,²⁵ targeting seafloor massive sulphides (SMS), ferromanganese crusts, and polymetallic nodules. Critically, the ISA has not yet finalized a regulatory regime for the extraction (exploitation) of seabed minerals and consequently, has not issued any exploitation contracts.²⁶ The application by the Republic of Nauru triggered the "two-year rule" within UNCLOS, compelling the ISA to establish standards for deep-sea mining while minimizing environmental risks.²⁷ Initially set for summer 2023, the deadline for these regulations has been extended to 2025.²⁸ Key issues anticipated to be addressed include environmental harm thresholds, environmental plan processes, monitoring programs, performance guarantees, compensation funds, and the management of transboundary harm affecting adjacent coastal states.²⁹

It is pertinent to note that the United States (US) is not a party to UNCLOS. Notwithstanding, the US has its own domestic legislation governing deep seabed mining within its jurisdiction³⁰. The Deep Seabed Hard Mineral Resources Act (DSHMRA), enacted in 1980, permitted U.S. citizens to engage in the exploration and recovery of seabed minerals pending the establishment of an international agreement such as UNCLOS.³¹ The 96th Congress, in passing this act, recognized the potential global benefits of accessing resources like nickel, copper, cobalt, and

²² International Seabed Authority (ISA), 'Exploration Contracts' <<https://www.isa.org.jm/exploration-contracts/exploration-areas/>> accessed 14 May 2025.

²³ Greenpeace, 'Media Briefing: International Seabed Authority 29th Session' (16 July 2024).

²⁴ United Nations, 'The International Seabed Authority and Deep Seabed Mining' (UN Chronicle) <<https://www.un.org/en/chronicle/article/international-seabed-authority-and-deep-seabed-mining>> accessed 14 May 2025.

²⁵ ISA (n 14).

²⁶ International Institute for Strategic Studies (IISS), 'Uncharted territory: deep-sea mining and the underwater domain' (IISS, 2025) <<https://www.iiiss.org/online-analysis/online-analysis/2025/03/uncharted-territory-deep-sea-mining-and-the-underwater-domain/>> accessed 14 May 2025.

²⁷ International Seabed Authority (ISA), 'FAQ for Media' <<https://www.isa.org.jm/faq-for-media/>> accessed 14 May 2025.

²⁸ NCLOS Blog, 'Nauru and Deep-Sea Minerals Exploitation: A Legal Exploration of the 2-Year Rule' (NCLOS, 2021) <<https://site.uit.no/nclos/2021/09/17/nauru-and-deep-sea-minerals-exploitation-a-legal-exploration-of-the-2-year-rule/>> accessed 14 May 2025.

²⁹ Ibid.

³⁰ US Code, 'Deep Seabed Hard Mineral Resources' <<https://uscode.house.gov/view.xhtml?path=/prelim@title30/chapter26&edition=prelim>> accessed 14 May 2025.

³¹ Ibid

manganese. The DSHMRA aimed to support the development of a comprehensive UNCLOS and ensure that all exploration and recovery activities were conducted safely and with environmental responsibility.³²

Under the Deep Seabed Hard Mineral Resources Act (DSHMRA), the National Oceanic and Atmospheric Administration (NOAA) is tasked with assessing the environmental impacts of deep seabed mining activities undertaken by U.S. citizens. The Act also established a framework for NOAA to issue exploration licenses and commercial recovery permits. Prior to granting any such authorizations, NOAA is legally obligated to prepare an environmental impact statement.³³ Despite the United States not being a signatory to UNCLOS, NOAA retains the authority to issue licenses under DSHMRA. For example, in 1984, NOAA granted exploration licenses for four sites within the Clarion-Clipperton Zone (CCZ), two of which, held by Lockheed Martin, remain active until June 2027. However, NOAA has not issued any commercial recovery permits, and the recognition of such permits by UNCLOS parties remains uncertain. U.S. companies engaged in deep-seabed mining in Areas Beyond National Jurisdiction (ABNJ) are also subject to other relevant federal legislation, including the Marine Mammal Protection Act³⁴ and the Clean Water Act.³⁵

2.2 Environmental Impact

The consequences of seabed mining on the marine environment remain largely uncertain, a situation stemming from the fact that commercial-scale deep-seabed extraction in international waters has yet to commence. To better understand these potential impacts, seabed mining companies are collaborating with scientists to gather crucial environmental and biological data within deep-sea regions holding mineral resources.³⁶ As mandated by their exploration contracts with the International Seabed Authority (ISA), these companies share the collected data, aiming to illuminate the potential ecological disruptions that mining activities could trigger.³⁷ However, this collaborative approach has raised concerns among some stakeholders, who perceive a possible conflict of interest arising from industry-funded research.³⁸ While the collection of deep-sea data by independent scientific institutions is advocated by some, the considerable costs associated with such research present a significant hurdle.

Several potential environmental impacts of seabed mining have been identified. Firstly, the noise and vibration generated by mining operations can propagate vast distances underwater, potentially affecting marine mammals and other fauna near the ocean's surface.³⁹ The increased ambient noise could interfere with the

³² Ibid.

³³ 30 U.S.C. §1419(d).

³⁴ Marine Mammal Protection Act 16 USC §§ 1361-1423h.

³⁵ 33 U.S.C. §§1251-1387.

³⁶ METALS.CO, 'DeepGreen Partners with Global Research Institutions to Advance Deep Sea Science Program' <<https://metals.co/deepgreen-partners-with-global-research-institutions-to-advance-deep-seascience-program/>> accessed 14 May 2025.

³⁷ Ibid.

³⁸ Ibid.

³⁹ Elham Shabahat, "Antithetical to Science": When Deep-Sea Research Meets Mining Interests' (Mongabay, 4 October 2021) <<https://news.mongabay.com/2021/10/antithetical-to-science-when-deep-sea-research-meets-mining-interests/>> accessed 14 May 2025.

communication and echolocation abilities of cetaceans, impairing their capacity to detect predators, locate food and mates, and potentially leading to hearing damage and elevated stress levels.⁴⁰ Further, the unique and often harsh conditions of the deep sea have resulted in slow-growing and fragile ecosystems. Consequently, deep-sea organisms are expected to exhibit limited resilience to disturbances such as seabed mining, which could lead to significant biodiversity loss. In addition, the physical removal of mineral nodules by mining activities can directly destroy habitats that certain deep-sea species rely upon for survival.

Beyond direct habitat destruction and noise pollution, seabed mining could also disrupt critical natural processes, particularly those regulating carbon cycling in the deep ocean.⁴¹ Some scientists hypothesize that the disturbance of carbon burial in sediments could have far-reaching effects on carbon sequestration and global climate regulation. Additionally, the processing of recovered materials at the ocean surface and their subsequent transport to land pose additional environmental risks to the near-surface environment.⁴² The discharge of sediment back into the ocean can increase water turbidity, thereby inhibiting photosynthesis in plankton, the base of many marine food webs.⁴³ Also, potential overflows from mining platforms and increased vessel traffic introduce threats such as ship strikes and the discharge of ballast water and other wastes, further endangering surface-dwelling marine life.

3. SUSTAINABLE USE AND MANAGEMENT OF THE ABNJ

The sustainable utilisation and management of areas beyond national jurisdiction (ABNJ) are central to the concept of the blue economy.⁴⁴ Coined by the United Nations (UN), the blue economy denotes environmentally sustainable economic growth derived from ocean resources.⁴⁵ It is posited as a strategy for maintaining economic expansion and generating employment, crucial for poverty reduction amidst increasing resource limitations and the climate crisis.⁴⁶ The fundamental aim is to promote economic advancement, social inclusivity, and the preservation or improvement of livelihoods, concurrently ensuring the ecological sustainability of oceans and coastal regions. This inherently involves decoupling socioeconomic development within ocean related sectors and activities from environmental and ecosystem degradation, an approach substantiated by scientific evidence indicating the finite nature of ocean resources and the significant deterioration of ocean health due to anthropogenic activities.⁴⁷

⁴⁰ Ibid.

⁴¹ Holly Niner and others, 'Deep-Sea Mining with No Net Loss of Biodiversity—An Impossible Aim' (2018) 5 *Frontiers in Marine Science* <https://research-management.mq.edu.au/ws/portalfiles/portal/85401859/Publisher_version.pdf> accessed 14 May 2025.

⁴² World Bank, *The Potential of the Blue Economy: Increasing Long-term Benefits of the Sustainable Use of Marine Resources for Small Island Developing States and Coastal Least Developed Countries* (2017) <<https://documents.worldbank.org/curated/en/523151496389684076/pdf/115545-1-6-2017-14-48-41-BlueEconomyJun.pdf>> accessed 14 May 2025.

⁴³ Worldwide Fund for Nature (WWF) 'Principles for a Sustainable Blue Economy' (WWF, 2015) <https://wwf.panda.org/wwf_news/?247477/Principles%2Dfor%2Da%2DSustainable%2DBlue%2DEconomy> accessed 14 May 2025

⁴⁴ Ibid.

⁴⁵ (n 41).

⁴⁶ Ibid.

⁴⁷ Ibid.

While a universally accepted definition of the blue economy remains elusive, various organisations, including the Worldwide Fund for Nature (WWF), have proposed guiding principles.⁴⁸ The WWF emphasized that, a sustainable blue economy is characterised by the provision of social and economic benefits, such as enhanced food security, poverty alleviation, and increased employment opportunities.⁴⁹ It also entails the protection and maintenance of marine ecosystems, the adoption of clean technologies and renewable energy sources, and governance frameworks that are inclusive, transparent, and adaptive.⁵⁰ Achieving this necessitates that public and private stakeholders establish clear objectives, rigorously assess performance, formulate supportive policies, effectively manage marine resources, and acknowledge the interconnectedness of maritime and land-based economies.⁵¹ Additionally, collaborative efforts and the exchange of knowledge are indispensable for realising a sustainable future.

Notwithstanding the foregoing, the blue economy faces significant challenges. Historically, the perception of aquatic ecosystems as limitless and cost-free waste repositories has led to overuse and degradation, exacerbated by escalating demand, governance deficiencies, and insufficient legal framework implementation, notably UNCLOS.⁵² This competition often marginalises vulnerable groups like small-scale fishers. Despite UNCLOS's entry into force for Nigeria in 1986, its 2019 domestication through general incorporation neglected specific provisions and national needs⁵³.

Consequently, Nigeria lacks indigenous continental shelf regulations despite its coastal status. Technological, personnel, and financial constraints further impede its international seabed regime engagement, jeopardising its blue economy agenda.⁵⁴ As of September 2024, Nigeria announced deep seabed mining exploration.⁵⁵ In West Africa, particularly Nigeria, realising the blue economy is significantly impeded by UNCLOS's inadequacy regarding emergent maritime security issues like terrorism and trafficking, rendering it increasingly outdated.⁵⁶ While supplementary

⁴⁸ (n 42).

⁴⁹ Ibid.

⁵⁰ Ibid.

⁵¹ Ibid.

⁵² World Bank, 'Blue Economy Development Framework'

(2017) <<https://pubdocs.worldbank.org/en/446441473349079068/AMCOECC-Blue-Economy-Development-Framework.pdf>> accessed 14 May 2025.

⁵³ Tom Okunomo, 'Nigeria's Blue Economy: Prospects, Opportunities, and Challenges' (Punch, 2024) <<https://punchng.com/nigerias-blue-economy-prospects-opportunities-and-challenges/>> accessed 14 May 2025.

⁵⁴ Khadijah O. Yusuff and Elizabeth O. Ibidapo-Obe, 'Blue Economy in Nigeria: Focus Areas, Potentials and Challenges' (2024) 5(1) International Journal of Women in Technical Education and Employment <<https://fpiwit.edjournal.federalpolyilaro.edu.ng>> accessed 14 May 2025.

⁵⁵ Shulammit Olowofoyeku, 'FG Targets Deep Seabed Exploration, Mining for Economic Diversification, New Revenue Streams' (Maritime Today Online, 18 September 2024) <<https://marimetodayonline.com/fg-targets-deep-seabed-exploration-mining-for-economic-diversification-new-revenue-streams/>> accessed 14 May 2025.

⁵⁶ Ekundayo Oluwaremilekun Babatunde and Mutiat Mobolanle Abdulsalam, 'Towards Maintaining Peacefulness of the Sea: Legal Regime Governing Maritime Safety and Security in Nigeria' (2021) 12 Beijing Law Review <https://www.scirp.org/pdf/blr_2021053111152595.pdf> accessed 14 May 2025.

agreements exist, persistent safety and security challenges highlight their limited effectiveness.⁵⁷ A research gap also exists concerning the law of the sea's evolution and its impact on marine security and energy transition in Nigeria⁵⁸.

However, the 2023 adoption of the Agreement on Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction (BBNJ) by the United Nations (UN) aims to address biodiversity conservation in ABNJ.⁵⁹ While governments and civil society have largely welcomed it, private sector engagement has been muted, with ratification depending on national and regional actions. As of September 2024, 91 nations and the European Union had signed the Agreement, with 8 having completed ratification.⁶⁰ The BBNJ Agreement addresses four primary areas: marine genetic resources, area-based management tools (such as marine protected areas), environmental impact assessments, and capacity building and marine technology transfer.⁶¹ It also encompasses governance and funding mechanisms, leaving numerous implementation details to be determined post-ratification by the Conference of the Parties and its subsidiary bodies.⁶² The governance of ABNJ is characterised by complexity and fragmentation, with the UN Convention on the Law of the Sea (UNCLOS) providing the foundational legal framework, supplemented by specific agreements concerning seabed resources and transboundary fish stocks. The BBNJ Agreement represents the third implementing agreement to UNCLOS, adding another layer to an already intricate governance landscape.

4. OUTER SPACE

Escalating global population and resource demands are driving the exploration of space as a potential solution. Resource-rich celestial bodies, such as asteroids and the Moon with their water and precious metal deposits, are now targets for active technological development aimed at extraction. Asteroids are remnants from the formation of our solar system, dating back 4.6 billion years.⁶³ Asteroids vary significantly in size and exhibit irregular characteristics.⁶⁴ While most reside in the asteroid belt, Near-Earth Asteroids (NEAs) are more accessible, with around 18,000 identified to date. Certain NEAs pose a potential hazard due to their size and orbital proximity.

⁵⁷ Ibid.

⁵⁸ Ibid.

⁵⁹ United Nations, 'Agreement on Conservation and Sustainable Use of Marine Biological Diversity of Areas beyond National Jurisdiction' (2023) <<https://www.un.org/bbnjagreement/en>> accessed 14 May 2025.

⁶⁰ UN BBNJ Agreement, 'BBNJ Agreement' (UN, 2024) <<https://www.un.org/bbnjagreement/en>> accessed 14 May 2025; High Seas Alliance, 'Treaty Ratification Progress' (High Seas Alliance, 2024) <<https://highseasalliance.org/treaty-ratification/table-of-countries/>> accessed 14 May 2025.

⁶¹ BBNJ Agreement (n 61); SDG Knowledge Hub, 'Financing Our Ocean Commons: Operationalizing BBNJ Financial Mechanism' (SDG Knowledge Hub, 2024) <<https://sdg.iisd.org/commentary/guest-articles/financing-our-ocean-commons-operationalizing-bbnj-financial-mechanism/>> accessed 14 May 2025.

⁶² BBNJ Agreement (n 61).

⁶³ NASA, 'Asteroids: In Depth' (NASA, 28 July 2018) <<https://solarsystem.nasa.gov/small-bodies/asteroids/in-depth/>> accessed 14 May 2025.

⁶⁴ Ibid.

Asteroids are classified into compositional types (C, S, and M), C-type (clay and silicate), S-type (silicate and nickel-iron), and M-type (nickel-iron) with some containing economically significant metals like platinum.⁶⁵ The concentration of such metals in Earth's core renders space-based extraction potentially attractive. Similarly, substantial water ice reserves have been identified in permanently shadowed lunar craters, representing a potential resource for in-space propellant production. This has spurred proposals for the Moon as a space refuelling depot.⁶⁶

The burgeoning space mining industry faces significant legal ambiguities concerning the regulation of extractive activities on the Moon and asteroids under prevailing international and domestic legal frameworks.⁶⁷ Current technological limitations preclude human missions to NEAs for mining, necessitating reliance on robotic operations.⁶⁸ Unmanned spacecrafts are proposed for extracting water and mining metals, which could be utilized for in-space manufacturing or potentially returned to Earth.

However, the economic viability and market impacts of returning asteroidal metals remain under evaluation. Despite emerging prospecting technologies, comprehensive space mining capabilities remain largely theoretical and currently lack economic viability. Companies in this sector are exploring interim monetization strategies pending the realization of resource revenue, anticipated to be at least a decade away.

4.1 Legal Frameworks on the Outer Space

The Peaceful Uses of Outer Space established by the UN Committee consists of five treaties and five principles governing space activities, addressing non-appropriation, arms control, exploration freedom, liability, safety, interference prevention, notification, scientific investigation, resource exploitation, and dispute settlement, all emphasizing global benefit and cooperation.⁶⁹ A central tenet of these frameworks is that outer space and its benefits should serve to enhance global well-being and foster international cooperation. Compliance with these agreements is a prerequisite for any space mining operation.

⁶⁵ Jim Edwards, 'Goldman Sachs: space-mining for platinum is "more realistic than perceived"' *Business Insider* (6 April 2017) <<http://www.businessinsider.com/goldman-sachs-space-mining-asteroid-platinum-2017-4?r=UK&IR=T>> accessed 14 May 2025 (quoting Goldman Sachs analyst note) (observing that harvesting even one such asteroid "instantly tanks the entire platinum market" by flooding worldwide supply).

⁶⁶ NASA, 'NASA Radar Finds Ice Deposits at Moon's North Pole' <https://www.nasa.gov/mission_pages/Mini-RF/multimedia/feature_ice_like_deposits.html> accessed 14 May 2025.

⁶⁷ KECK Institute for Space Studies, 'Asteroid Retrieval Feasibility Study' (2 April 2012) 15 <https://www.kiss.caltech.edu/final_reports/Asteroid_final_report.pdf> accessed 14 May 2025 ("Sending a human to a Near-Earth Asteroid now requires months of flight time and consequent life support and radiation protection systems not yet designed.") [KECK STUDY].

⁶⁸ *Ibid.*

⁶⁹ United Nations Office for Outer Space Affairs, 'Treaties and Principles' <<https://www.unoosa.org/oosa/en/our-work/spacelaw/treaties.html>> accessed 14 May 2025.

The treaties commonly referred to as the five United Nations treaties on outer space include:

4.2 Outer Space Treaty

The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, establishes fundamental principles for the conduct of space activities.⁷⁰ The Outer Space Treaty serves as the foundational instrument of international space law. Ratified by over 100 nations, it not only aims to prevent military dominance in space but also has implications for commercial mining endeavours. Article I stipulates that the exploration and use of outer space should benefit all countries and be freely accessible to all states without discrimination.⁷¹ The treaty prohibits national appropriation of celestial bodies and mandates state authorization and supervision of all national space activities, whether governmental or private.⁷² However, ambiguities persist regarding the legality of space resource extraction, the precise definition of "celestial bodies" (likely encompassing asteroids), and the ownership rights of private entities over extracted resources. While the Outer Space Treaty does not explicitly permit or forbid the extraction and consumption of space resources, the prevailing interpretation, supported by the International Institute of Space Law, suggests that commercial exploitation is permissible as long as it does not impede similar activities by other entities.⁷³ This theory posits that while in-situ natural resources are part of the celestial body and not subject to ownership, once extracted, they may be appropriated for commercial purposes.⁷⁴

4.3 Rescue Agreement

The Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space outlines obligations for the rescue and return of astronauts and space objects and provides the framework for the return of astronauts and space objects re-entering Earth's atmosphere.

4.4 Liability Convention

The Convention on International Liability for Damage Caused by Space Objects sets forth the framework for liability arising from damage caused by space objects.

⁷⁰ Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (adopted 27 January 1967, entered into force 10 October 1967) 18 UST 2410, 610 UNTS 205 (Outer Space Treaty).

⁷¹ Ibid.

⁷² Ibid.

⁷³ Jinyuan Su, 'Legality of Unilateral Exploitation of Space Resources Under International Law' (2017) 66 International & Comparative Law Quarterly 991 <<https://www.cambridge.org/core/journals/international-and-comparative-law-quarterly/article/abs/legality-of-unilateral-exploitation-of-space-resources-under-international-law/EE17641F7B7C6404A79B77AEB627D5F4>> accessed 14 May 2025.

⁷⁴ Ibid.

4.5 Registration Convention

The Convention on Registration of Objects Launched into Outer Space mandates the registration of space objects launched into orbit with a UN administered registry.

4.6 Moon Agreement

The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies addresses activities on the Moon and other celestial bodies, including resource exploitation. The Moon Treaty, although having fewer signatories and considered by some as outdated, explicitly declares the Moon and its natural resources (including asteroids) as the common heritage of all mankind potentially hindering private resource extraction.

4.7 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space

Complementing the above treaties are five declarations and legal principles adopted by the UN General Assembly namely: the Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space,⁷⁵ the Broadcasting Principles,⁷⁶ the Remote Sensing Principles,⁷⁷ the Nuclear Power Sources Principles,⁷⁸ and the Benefits Declaration principles.⁷⁹ These address areas such as broadcasting, remote sensing, the use of nuclear power sources in space, and the imperative of international cooperation for the benefit of all states, particularly developing nations. The United Nations Office for Outer Space Affairs (UNOOSA) has developed the Accessing Space Treaty Resources Online (ASTRO) database, which compiles these international space law instruments and their ratification statuses.⁸⁰

Recognizing the regulatory uncertainties surrounding space resource development, the Hague International Space Resources Governance Working Group underscores the international community's recognition of the emerging need for a more comprehensive regulatory framework for space resource development.⁸¹ Their draft 'building blocks' represent a significant step towards establishing principles for the responsible and equitable utilization of space resources.⁸² These proposed principles, rooted in international law, emphasize include international responsibility, unrestricted access to space resources, sustainable utilization, due regard for the interests of all countries and humankind., monitoring and redress of harmful impacts, benefit-sharing mechanisms, liability for damage, and the establishment of appropriate institutional arrangements, including an international registry for priority

⁷⁵ General Assembly Resolution 1962 (XVIII) (13 December 1963).

⁷⁶ General Assembly Resolution 37/92 (10 December 1982).

⁷⁷ General Assembly Resolution 37/92 (10 December 1982).

⁷⁸ General Assembly Resolution 47/68 (14 December 1992).

⁷⁹ General Assembly Resolution 51/122 (13 December 1996).

⁸⁰ Francis Lyall and Paul B Larsen, *Space Law: A Treatise* (2nd edn, Routledge 2018).

⁸¹ Lotta Viikari, 'Governing the Final Frontier: The Hague Working Group on Space Resources Governance' (2018) 28 Finnish Yearbook of International Law 185.

⁸² Ram S Jakhu, 'The Need for a Multilateral Agreement on the Exploration, Exploitation and Utilization of Space Resources' (2019) 7(1) *New Space* 3.

rights and mechanisms for the lawful acquisition and mutual recognition of property rights.⁸³

The building blocks recommend that states and intergovernmental organizations assume responsibility for space resource activities by enacting national legislation consistent with international legal principles.⁸⁴ The framework underscores the importance of due regard for the interests of other nations, the monitoring and mitigation of harmful impacts, and the equitable sharing of benefits, promoting inclusive participation from all countries. Liability for damage and the creation of an international repository for information and best practices are also identified as crucial components of this emerging legal landscape.⁸⁵

4.8 Sustainable Use of the Outer Space

Space sustainability, drawing upon foundational principles of terrestrial sustainable development, centres on two key concepts: meeting present needs and acknowledging environmental limitations imposed by technology and social organization in satisfying both current and future needs. These concepts are equally pertinent in the space environment.⁸⁶

The Moon Agreement offers an early example by distinguishing between resource utilization for scientific or survival purposes and more extensive commercial activities. The Secure World Foundation⁸⁷ defines space sustainability as ensuring the long-term peaceful and socioeconomic benefits of outer space for humanity. The increasing centrality of this concept is underscored by UNIDIR, highlighting the intrinsic link between continued access to and utilization of space and the ability of stakeholders to explore and benefit from it. Consequently, sustainable practices are paramount for all space activities.⁸⁸

International space law is beginning to incorporate these sustainability principles. Earth-based sustainable mining practices emphasizing minimal environmental impact, equitable benefit sharing, and the use of capital for social good offer a potential model for space resource activities.⁸⁹ Such activities could be deemed sustainable if they minimize harm to the space environment, ensure shared benefits, and contribute to socio-economic well-being on Earth through job creation or other societal benefits. While the existing treaties, with the exception of the Moon Agreement (limited to its State Parties), do not directly address space resource activities or sustainability, their foundational principles remain relevant.

⁸³ Ibid.

⁸⁴ Stephen E Doyle, 'Space Resources and the Law: A Pragmatic Perspective' (2018) 43(4) *Air and Space Law* 369.

⁸⁵ Fabio Tronchetti, 'The Hague International Space Resources Governance Working Group: Towards a Framework for the Governance of Space Resources' (2018) 24(4) *Space Policy* 337.

⁸⁶ United Nations Office for Outer Space Affairs, *Guidelines for the Long-term Sustainability of Outer Space Activities* (UNOOSA 2021).

⁸⁷ Secure World Foundation, *Space Sustainability* (Secure World Foundation) <https://swfound.org/our-focus/space-sustainability/> accessed 15 May 2025.

⁸⁸ United Nations Institute for Disarmament Research, *Space Security Programme* (UNIDIR) <https://unidir.org/files/2023-08/UNIDIR_To_Space_Security_and_Beyond_Report.pdf> accessed 15 May 2025.

⁸⁹ Ibid.

COPUOS has been actively engaged in this area. Their 2016 report stressed the need to maintain a safe, secure, and sustainable space environment, advocating for the limitation of space debris and recognizing the finite nature of Earth's orbital environment. The adoption of the 21 voluntary and non-binding Long-term Sustainability Guidelines in 2019, while primarily focused on LEO, provides valuable insights for broader sustainable space regulation.

Guideline A.2 explicitly links space sustainability to the UN's Sustainable Development Goals (SDGs), emphasizing the interconnectedness of economic, social, and environmental sustainability. These 17 SDGs, aiming for climate-sensitive, biodiversity-respecting, and resilient development, are crucial for guiding space activities, which play a significant role in their achievement. Effective implementation and monitoring of these guidelines necessitate international cooperation, given the varying capacities and experiences of nations in managing space activities. Collaborative efforts and support from experienced spacefaring nations are essential for success. Furthermore, frameworks like the GEGSLA recommendations and the Vancouver Recommendations on Space Mining offer additional regulatory pathways for the sustainable use of outer space.

In essence, the evolution of space sustainability in international law involves adapting established terrestrial sustainable development principles to the unique context of outer space, addressing the growing challenges of space debris and resource utilization through international cooperation and the development of both binding and non-binding guidelines. The integration of the SDGs provides a comprehensive framework for ensuring that humanity's ventures into space contribute to, rather than detract from, a sustainable future for all.

5. NIGERIA'S SPACE JOURNEY AND THE SIGNIFICANCE OF ITS SPACE LAW FRAMEWORK

Nigeria's proactive engagement in space exploration, evidenced by its early adoption of the Artemis Accords⁹⁰ and the establishment of a comprehensive national space program⁹¹, underscores its recognition of space technology as a catalyst for socio-economic advancement. As one of the first African nations to sign the Artemis Accords, Nigeria strategically positions itself for potential benefits in international collaboration, investment attraction, and capacity building within its burgeoning space sector.⁹² This commitment aligns with its historical trajectory in space activities, marked by the early National Aeronautics and Space Administration (NASA) tracking station in Kano and the subsequent establishment of National Space Research and Development Agency (NASRDA).

⁹⁰ United States Department of State, 'Nigeria and Rwanda: First African Nations Sign the Artemis Accords' (United States Department of State, 13 December 2022) <<https://www.state.gov/nigeria-and-rwanda-first-african-nations-sign-the-artemis-accords/>> accessed 15 May 2025.

⁹¹ Federal Parastatals, Agencies and Initiatives, 'NASRDA' <<https://fga.gov.ng/agency/national-space-research-and-development-agency-nasrda/>> accessed 15 May 2025.

⁹² Space in Africa, 'NASRDA Secures NGN 20 Billion Take-Off Fund to Enforce Space Regulation in Nigeria' (3 April 2025) <<https://spaceinafrica.com/nasrda-secures-ngn-20-billion-take-off-fund-to-enforce-space-regulation-in-nigeria/>> accessed 15 May 2025.

NASRDA's pivotal role in regulating Nigeria's space endeavours and driving its strategic objectives, including the development of research centres, demonstrates a focused approach to leveraging space technology for national development.⁹³ While challenges such as resource allocation and the complexities of international partnerships persist, Nigeria's adherence to international space law through its ratification of key treaties and the enactment of the NASRDA Act provides a robust legal foundation for its space ambitions. The NASRDA Act, in particular, signifies a commitment to fostering private sector involvement and developing crucial capabilities through centres like the National Centre for Remote Sensing, potentially positioning Nigeria as a leader in space science and technology within the African continent. Addressing the identified challenges will be crucial for Nigeria to fully capitalize on its space program and international collaborations, ultimately translating its space aspirations into tangible national progress.

6. ANTARCTIC AREAS

The Antarctic region presents a unique case in global resource management and jurisdiction due to the absence of a formal government. Instead, it is governed by the Antarctic Treaty System (ATS),⁹⁴ which came into force in 1961. This treaty designates Antarctica as a scientific preserve, prohibiting military activities, ensuring freedom for scientific research, and safeguarding the continent's environment.

Two key features distinguish the ATS: first, it establishes that no new claims of sovereignty will be recognized while the treaty remains in effect. Second, the Protocol on Environmental Protection to the Antarctic Treaty (the Madrid Protocol), effective since 1998,⁹⁵ imposes a comprehensive ban on all mineral resource activities, with the exception of scientific research. This strict international treaty regime governing Antarctic resources contrasts sharply with the management of resources in areas like the deep seabed and outer space.⁹⁶ While these other global commons are also subject to international agreements, discussions around resource extraction and use beyond national jurisdiction are more prevalent. Therefore, while Antarctica exists outside national sovereignty claims, its resources are subject to an explicit prohibition on extraction, setting it apart from other regions considered global commons.

Notwithstanding the ban, various natural resources, including silver, copper, gold, nickel, platinum, iron ore, chromium, cobalt, molybdenum, zinc, manganese, lead, titanium, nickel, and uranium, have been identified in Antarctica. Minimal, non-

⁹³ Space in Africa, 'The Impact of Nigerian Constitution On The Non-Ratified Treaties Of Space Law' (4 March 2020) <<https://spaceinafrica.com/the-impact-of-nigerian-constitution-on-the-non-ratified-treaties-of-space-law/>> accessed 15 May 2025.

⁹⁴ Antarctic Treaty Secretariat, The Antarctic Treaty (2010) https://www.ats.aq/documents/ats/treaty_e.pdf accessed 15 May 2025. (This is the official text of the treaty itself).

⁹⁵ Protocol on Environmental Protection to the Antarctic Treaty (1991) https://www.ats.aq/documents/ats/madrid_protocol_e.pdf accessed 15 May 2025. (The official text of the Madrid Protocol).

⁹⁶ GIGA Hamburg, 'Now and Never: Banning Hydrocarbon Extraction in Antarctica Forever' (3 May 2022) GIGA Focus Global <https://www.giga-hamburg.de/en/publications/giga-focus/now-and-never-banning-hydrocarbon-extraction-in-antarctica-forever> accessed 15 May 2025.

commercial quantities of coal and hydrocarbons have also been located.⁹⁷ Further, geological and geophysical evidence suggests potential petroleum reserves offshore, particularly within the sedimentary basins of the Filchner, Ronne, and Amery Ice Shelves, the Ross Sea and Ice Shelf, and the Weddell Sea. Currently, the extraction of these minerals is economically and physically challenging due to the harsh climate, extensive ice cover, and remote locations.⁹⁸

However, advancing technologies are gradually increasing the feasibility of such operations. Concurrently, growing global environmental awareness is shifting concerns towards the protection of Antarctica's pristine environment. The risk of resource extraction is also amplified by the increasing accessibility resulting from the shrinking Antarctic ice sheet. Under severe climate change scenarios, ice-free areas could expand significantly by the end of the century, particularly on the Antarctic Peninsula, potentially unlocking mineral resource availability and causing substantial environmental alterations.

6.1 Legal Frameworks on the Antarctic Zones

The regulation of potential mineral resource activities within the Antarctic Treaty System (ATS) began in 1970 when the United Kingdom and New Zealand were approached by mineral companies interested in commercial geophysical exploration in the Southern Ocean.⁹⁹ This inquiry initiated a prolonged and highly contentious debate, dominating Antarctic politics throughout the 1980s and early 1990s. Recognizing the potential for significant environmental and political repercussions, the Treaty nations adopted a precautionary stance in 1976, implementing a voluntary moratorium on the exploration and exploitation of Antarctic minerals.

Despite the complexities involved, this initial moratorium paved the way for negotiations aimed at establishing a comprehensive minerals regime. These discussions culminated in the adoption of the Convention on the Regulation of Antarctic Mineral Resource Activities (CRAMRA) in 1988. CRAMRA's objective was to govern all phases of mineral activity, stipulating that mining could only proceed if all Parties unanimously agreed that no environmental risks were present. This period also witnessed a notable increase in global interest in Antarctica, with the number of signatories to the Antarctic Treaty expanding from 25 to 38.

However, CRAMRA faced significant opposition from a powerful international environmental campaign, spearheaded by organizations such as Greenpeace and the Worldwide Fund for Nature. These groups advocated strongly for a complete ban on mineral exploitation and the designation of Antarctica as a 'World Park'. The pressure exerted by these campaigns proved decisive when, in 1989, Australia and France chose not to sign CRAMRA. This refusal effectively prevented the agreement from entering into force, as its ratification required unanimous consent from all Treaty

⁹⁷ Ibid.

⁹⁸ Mongabay, 'Melting Antarctic ice could weaken world's strongest ocean current, study warns' (8 April 2025) <https://news.mongabay.com/short-article/melting-antarctic-ice-could-weaken-worlds-strongest-ocean-current-study-warns/> accessed 15 May 2025.

⁹⁹ New Zealand Ministry of Foreign Affairs and Trade, 'The Antarctic Treaty System' <https://www.mfat.govt.nz/en/environment/antarctica-and-the-southern-ocean/the-antarctic-treaty-system/> accessed 15 May 2025.

nations. By 1990, a shift in perspective saw several countries, including Australia, France, New Zealand, Italy, and Belgium, proposing a comprehensive environmental protection convention for Antarctica, while others, such as the UK, Japan, and the USA, initially resisted a permanent mining ban.

The failure of CRAMRA represented a critical juncture for the Antarctic Treaty System, marking its first major threat. In response to this impasse, the United Kingdom and Chile convened a special meeting to develop comprehensive environmental protection measures. This initiative led to the drafting and subsequent signing of the Protocol on Environmental Protection to the Antarctic Treaty in 1991. This Protocol incorporated several definitions and measures from CRAMRA but ultimately established a definitive ban on all mineral resource activities in Antarctica, with the sole exception of scientific research. The demise of CRAMRA underscores the delicate nature of the ATS consensus process.

7. SUMMARY

The principle governing the use of resources beyond national jurisdiction calls for cooperative management for the 'common heritage of humankind.' This is understood as creating a trusteeship dedicated to safeguarding the interests of humanity as a whole, rather than those of specific states or private entities. A core aspect of this principle is the active and equitable sharing of benefits including financial, technological, and scientific advancements derived from these resources. This aims to establish a just foundation for limiting public and private commercial advantages and prioritizing distribution, notably to developing nations, thereby fostering intragenerational equity.

Recognizing certain areas as the collective heritage of humanity implies that their resources should be accessible for the benefit and use of all, while also considering the needs of future generations and the development of less industrialized countries. The overarching objective is the sustainable development of these shared spaces and their resources, with its tenets potentially reaching beyond conventional applications. Nevertheless, significant legal concerns exist concerning all facets of these resources beyond national jurisdiction and these subjects the regimes governing globally significant resources, irrespective of location, to critical examination. Consequently, it challenges fundamental concepts of traditional international law, such as territorial acquisition, sovereignty, sovereign equality, and international personality, alongside the allocation of planetary resources and consent as a basis for international law. Notably, the established framework for ocean management has long been considered a potential blueprint for the future organization of an increasingly interdependent world.

The requirement for equitable utilization (or equitable benefit sharing), which necessitates the distribution of financial, technological, and scientific benefits from the use of resources beyond national jurisdiction, has generated significant division, particularly between developed and developing states and corporate entities. While developing states often consider this element of the global commons essential for achieving distributive justice, developed states may perceive it as a potential obstacle to investment and the utilization of market mechanisms, such as property rights, to realize economic and environmental gains.

8. CONCLUSION

Drawing upon the preceding doctrinal and comparative legal analysis of resource governance beyond national jurisdiction, encompassing the legal regimes applicable to the deep-sea bed, high seas, outer space, and the Antarctic zones, this conclusion synthesizes the key insights derived from examining the UNCLOS, the Outer Space Treaty, and the ATS. While these international legal instruments establish crucial normative and institutional frameworks for the management of these global commons, the study reveals that their efficacy in balancing competing state interests with the imperative of long-term sustainability and equitable access demonstrates considerable variance across these distinct legal and ecological environments.

Therefore, the findings underscore that while these foundational legal structures provide essential frameworks, their effectiveness in ensuring truly sustainable and equitable resource governance beyond national jurisdiction is contingent upon continuous adaptation, robust enforcement, and proactive measures to address emerging challenges and scientific uncertainties. The pursuit of resource driven development by nations must be carefully calibrated against the imperative of safeguarding the long-term health and integrity of these shared global environments, consistent with the principles of international law and for the benefit of humankind.

9. RECOMMENDATIONS

Building upon the identified strengths and limitations of the current legal landscape, the following recommendations are proposed:

- (a) **Bolster Adaptive International Cooperation:** Elevate international collaboration beyond mere upholding of existing frameworks. This necessitates proactive engagement in negotiating and implementing adaptive mechanisms that can respond effectively to evolving scientific understanding, technological advancements, and geopolitical shifts within each global common. This includes establishing clear pathways for regular review and amendment of existing agreements.
- (b) **Strengthen and Universalize Specific Regulatory Regimes:** While UNCLOS and the BBNJ Agreement represent significant steps for marine biodiversity, concerted global efforts are needed to ensure their universal ratification and effective implementation. Furthermore, drawing lessons from the Antarctic Treaty System, the international community should explore the feasibility of developing more specific and robust regulatory regimes for resource activities in outer space, addressing issues such as resource extraction, space debris mitigation, and equitable benefit-sharing.
- (c) **Advance Integrated Ecosystem-Based Management with Precautionary Principles:** Move beyond simply considering cumulative impacts to implementing truly integrated ecosystem-based management frameworks. This requires the adoption of a strong precautionary principle, particularly in the face of scientific uncertainty, ensuring that the burden of proof lies with

those proposing resource exploitation to demonstrate environmental safety and long-term sustainability.

- (d) Invest in Transparent and Independent Monitoring and Robust Enforcement: Enhance monitoring capabilities through the development and deployment of independent, transparent, and internationally verifiable technologies across all global commons. Simultaneously, strengthen enforcement mechanisms by establishing clear lines of responsibility, effective dispute resolution mechanisms, and proportionate penalties for non-compliance. This may involve the creation of dedicated international bodies or the empowerment of existing ones with greater authority and resources.
- (e) Foster Interdisciplinary Research, Innovation, and Equitable Knowledge Sharing: Significantly increase investment in interdisciplinary research that integrates environmental, social, economic, and technological perspectives on resource governance. Encourage and facilitate international collaboration in the development and dissemination of sustainable technologies and best practices. Crucially, establish mechanisms for equitable sharing of knowledge, data, and benefits derived from resource utilization in these areas, ensuring that the interests of all humanity, particularly developing nations, are duly considered.