DIVING INTO THE ABYSS: Deep Sea Mining Unveiled

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***[Abstract**: Deep-sea mining is an emerging industry that aims to extract valuable mineral resources, such as manganese nodules, ferromanganese crusts, and seafloor massive sulfide deposits, from the ocean floor. These minerals are critical for various applications, including renewable energy, electronics, construction materials, and technologies. Recognizing the potential advantages of reducing import dependence, supporting the economy, and mitigating environmental issues associated with conventional land-based mining, public and private institutions, including those in India, have rekindled their interest in deep-sea mining, which was once deemed economically and technically unviable in the early 1980s. Numerous research projects are currently underway to understand the economic, environmental, socio-legal implications of commercial deep-sea mining operations. This endeavor is challenging due to the intricate direct impacts and spillover effects involved. This paper provides a comprehensive overview of the existing legal framework surrounding deep-sea mining and the knowledge in these fields. Additionally, it compares the environmental impacts of deep-sea mining with those of traditional land-based mining. The International Seabed Authority (ISA) plays a pivotal role in developing regulations for deep-sea mining, making its progress a focal point of this article. The regulations formulated by the ISA will establish the standards for effective environmental management in the deep-sea mining industry. Furthermore, the article identifies critical legal and knowledge gaps that necessitate urgent attention to ensure safe, efficient, and environmentally sound practices in deep-sea mining, benefiting not only the global community but also specifically India. Finally, it emphasizes the significance of interdisciplinary research and international cooperation in addressing these challenges effectively.]*

I

Navigating the Green Transition: Unlocking the Potential of Deep-Sea Mining

Back in 1992, when global warming debates blazed like wildfire, a visionary gathering of 158 nations sparked a revolution- the United Nations Framework Convention on

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Climate Change (UNFCCC).[1] This historic alliance recognised climate change as an urgent call to action. Fast forward through the decades, and we witness the birth of the Paris Agreement,[2] the Kyoto Protocol,[3] and a host of initiatives united by a common purpose: sustainable development. The Sustainable Development Goals (SDGs) set forth by each state catalyzed the global transition from coal & fossil fuels to clean and sustainable sources of energy. However, the shift towards a greener economy is expected to result in a higher need for minerals like cobalt, lithium, nickel, copper, vanadium, and indium. These minerals are crucial for producing electric vehicles, green energy technologies, and storage batteries[4]. The International Energy Agency estimated that the advancement of clean energy technologies would require at least a four-fold increase in production by 2050.[5] In other words, it is crucial to prioritize the establishment of robust and secure supply chains of the required metals to ensure a hassle-free transition.

In the current landscape, nations undergoing such a shift are primarily reliant on terrestrial mining to procure the necessary metals. Ironically, the land-based mining also entails similar implications for the environment. The mining adversely affects the surrounding terrestrial environment leading to the destruction of habitat and loss of biodiversity, soil erosion, soil pollution and water contamination.[6] Globally, terrestrial mining is a major contributor of deforestation,[7] with huge swaths of forests removed for excavation pits,[8] access roads and workers' settlements. Furthermore, since the metal ores are distributed extremely disproportionately across the world, only a handful of nations have secured a large majority of the critical metals which creates unfair trade

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[1]UNITED NATIONS: UN CHRONICLE, *From Stockholm to Kyoto: A Brief History of Climate Change* (Jun. 2007) *available at:* https://www.un.org/en/chronicle/article/stockholm-kyoto-brief-history-climate-change(last visited Apr. 20, 2023).

[2]Paris Agreement to the United Nations Framework Convention on Climate Change, Dec. 12, 2015, T.I.A.S. No. 16-1104.

[3]Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 2303 U.N.T.S. 162.

[4]Sven Teske *et. al*., ACHIEVING THE PARIS CLIMATE AGREEMENT GOALS (2019).

[5]IEA 50, *Energy Technology Perspectives 2023available at*: https://www.iea.org/reports/energy-technology-perspectives-2023 (last visited Apr. 21, 2023).

[6]C. B. Dissanayake *et. al*., *Environmental Impact of Mining, Erosion and Sedimentation in Sri Lanka*, LI IJES1, 35-50 (1996).

[7]Stefan Giljum *et. al*., *A Pantropical Assessment of Deforestation Caused by Industrial Mining,*CXIX PNAS 38 (2022).

[8]MONGABAY, *Mining may contribute to deforestation more than previously thought, report says*(Apr. 20, 2023) *available at*: https://news.mongabay.com/2023/04/mining-may-contribute-to-deforestation-more-than-previously-thought-report-says/.

practices disincentivizing the clean energy transition.[9] Almost 75% of the total metal ores are in the possession of only three nations- China, Democratic Republic of Congo and Australia.[10] But, most importantly, researchers estimate that the current land reserves are not even capable of facilitating a complete transition to green energy before running out.[11] At this juncture, exploring the diverse resources lying in abundance in the deep sea to fulfill the needs of the future may be necessitated.

II

The Ethical Crossroads of Deep-Sea Mining

"In the heart of debate, the nodule's tale is told, Proponents foresee salvation, opponents fear nature's threshold. Amidst the clash of views, wisdom seeks its way, Balance in exploration, tomorrow's harmony we pray."

The Natural History Museum of London proudly showcases a seemingly ordinary dark lump, yet it possesses a captivating secret. Despite its coal-like appearance, this small nugget holds immense value as a polymetallic nodule, one among trillions scattered across the ocean floors. These unassuming nodules contain precious resources like manganese, nickel, cobalt, and copper, located on the seabed in the form of marine nodules, ferromanganese crusts, and massive polymetallic sulphides[12]. In the Pacific Ocean's Clarion-Clipperton Zone (CCZ) alone, there exists six times more cobalt and three times more nickel there than in the world's entire land-based reserves[13].The World Bank reported that by utilizing deep-sea mining, the production of minerals like cobalt could increase by nearly 500 per cent by 2050 to meet the growing demand for clean energy technologies.[14] These riches have attracted the interest of public & private actors alike, who argue that extracting these nodules should be a global priority, as they have the potential to combat climate change stemming from carbon-emitting industries.

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[9]IEA 50, *The Role of Critical Minerals in Clean Energy Transitions* (May 2021*) available at* :https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions?ref=energyvsclimate.com (last visited Apr. 20, 2023).

[10]*Id.*

[11]*Id.*

[12]NATURAL HISTORY MUSEUM, *Biodiversity in deep-sea mining exploration areas available at*: https://www.nhm.ac.uk/our-science/our-work/biodiversity/deep-sea-systematics-ecology-group/establishing-biodiversity-baselines-deep-sea-mining.html (last visited Apr. 20, 2023).

[13]Alexander Cunningham, *Assessing the feasibility of deep-seabed mining of polymetallic nodules in the Area of seabed and ocean floor beyond the limits of national jurisdiction, as a method of alleviating supply-side issues for cobalt to US markets*, I SSBM 1–20 (2022).

[14]THE WORLD BANK, *Mineral Production to Soar as Demand for Clean Energy Increases* (May 11, 2020*) available at*:https://www.worldbank.org/en/news/press-release/2020/05/11/mineral-production-to-soar-as-demand-for-clean-energy-increases (last visited Apr. 20, 2023).

These entities are now lining up to get approved for exploration contracts from the International Seabed Authority (ISA), (which shall be delineated in the forthcoming section) the UN body responsible for controlling mining in international waters. Till now, the ISA has approved 31 exploration contracts governed by the *Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area*.[15]

However, the exploitation of these deep seabed resources is questioned by many, citing concerns in relation to their extensive degrading effect on the marine environment and the introduction of pollutants in the water bodies. These concerns arise primarily from the way deep-sea mining operations are conducted. The prevailing idea involves using specialized collector vehicles to rake the seabed, collecting potato-sized nodules filled with metal ores, which are then vacuumed up onto a ship.[16] Unfortunately, this process generates a plume of sediments known as the "collector plume." Additionally, the collected nodules are separated from unwanted sediment on the ship, which is subsequently discharged into the ocean, forming a "discharge plume." Scientists express concern over the diffusion of sediment plumes, citing the "Disturbance Recolonisation experiment" (DISCOL) conducted in 1989 by German scientist Hjalmer Thiel.[17] The experiment simulated nodule extraction by deploying a plow harrow across an eleven square kilometer section of the seafloor in the Peru basin.[18] When scientists revisited the site twenty-six years later, they discovered lasting damage to biodiversity and seafloor erosion.[19] Similar research in the Netherlands revealed a 31% loss of links in the ecosystem's food chain due to nodule removal.[20]

Researchers, opposing deep-sea mining, on account of these reasons argue that deep-sea mining of these nodules would have disastrous consequences for our already-strained oceans, plagued by plastic pollution and rising temperatures. Delicate and long-lived deep-sea organisms, including polychaete worms, sea cucumbers, corals, and squid, would face annihilation due to dredging activities. Moreover, toxic metals present in sediment plumes stirred up during mining would poison marine food chains.[21]This ethical debate has evolved into a polarized dispute, enveloping biologist

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[15]INTERNATIONAL SEABED AUTHORITY, *Exploration Contracts available at*: - https://www.isa.org.jm/exploration-contracts/ (last visited Apr. 20, 2023).

[16]Jorge Parada *et. al.*, THE DEEP SEA ENERGY PARK: HARVESTING HYDROTHERMAL ENERGY FOR SEABED EXPLORATION(2012).

[17]DISCOL, *Initial Impact Study available at*: https://www.discol.de/initial-impact-study/ (last visited Apr. 20, 2023).

[18]*Id.*

[19]Eric Simon-Lledó*et. al.*, *Biological effects 26 years after simulated deep-sea mining*, IX SCI. REP.8040 (2019).

[20]EOS, *The 2-Year Countdown to Deep-Sea Mining* (Jan. 24. 2022) *available at*: https://eos.org/features/the-2-year-countdown-to-deep-sea-mining (last visited Apr. 20,2023).

[21]Robert A. Judge *et. al*., SUBSEA SLURRY LIFT PUMP FOR DEEPSEA MINING181 (2010).

against geologist, conservationist against environmentalist, and manufacturers against suppliers. It highlights the world's predicament: the need for sustainable energy sources that reduce greenhouse gas emissions while requiring the extraction of metals and resources that contribute to global warming and impact biodiversity. As nations commit to lowering emissions, the conflict now revolves around determining which ecosystems we are willing to sacrifice in pursuit of a fossil fuel-free future. To address this, we must thoroughly weigh the consequences and examine the legal framework surrounding the notion of deep-sea mining.

III

Sustainability of Deep-Sea Mining: Worth taking a Risk?

The Principle of Sustainable Development is a crucial aspect of international environmental law, addressing the consideration of various circumstances, and is widely recognized and serves as the foundation for numerous international environmental agreements and declarations. The United Nations has provided a general definition of sustainability, emphasizing the importance of meeting present needs while ensuring the ability of future generations to meet their own needs. Sustainability research seeks to integrate environmental health, social equity, and economic vitality to create thriving, healthy, diverse, and resilient communities for both current and future generations.[22] This approach acknowledges the interconnectedness of these issues and requires a systems-oriented perspective that acknowledges complexity.

Over time, the concept of sustainable development has evolved from its initial focus on environmental pollution to encompass comprehensive interdisciplinary research. Scholars have proposed a definition for sustainable deep-sea mining that involves considering various aspects such as environmental sustainability, economic sustainability, biological sustainability, and energy use sustainability. The sustainability research of deep-sea mining plans aims to assess different designs, taking into account technological, economic, environmental, and social factors simultaneously, where the goal is to find a compromise or optimal balance among these influencing aspects.[23] In relation to the ethical debate we previously discussed, proponents of Deep-Sea Mining can only gain support if they can convincingly demonstrate that the benefits of such

[22]Justice Mensah *et. al*., *Sustainable development: Meaning, history, principles, pillars, and implications for human action: Literature review*, V Cogent Soc. Sci. (2019).

[23]Joel P. Clark *et. al*., *Mining manganese nodules: Potential economic and environmental effects ag*, IX Resour. Policy 75, 99-109 (1983).

mining outweigh its consequences.[24] However, the sustainability perspective reveals a complex issue, which does not gain support for the 'Optimal Balance' proposition. There are significant concerns regarding the potential risks that deep-sea mining poses, particularly its adverse effects on the deep-sea environment and ecosystems. Extensive research and attention are being dedicated to studying the biological resources found in the deep sea, such as animals, plants, and microorganisms, as they serve as indicators of ecological harm.

Deep-sea mining poses grave threats to the biological integrity of the marine ecosystem, with potential consequences that extend far beyond immediate localized impacts. The extraction of minerals from the ocean floor carries significant risks, including the blockage of breathing systems of seabed organisms due to the presence of suspended particles. These particles, introduced during mining activities, can obstruct delicate respiratory structures, leading to reduced oxygen intake and potentially fatal suffocation.[25] Another concerning impact of deep-sea mining is the disturbance caused by low-frequency noise and vibrations.[26] Seabed organisms rely on communication and specific behaviors such as hunting and courtship for their survival and reproduction. However, these crucial activities can be severely disrupted, jeopardizing the reproductive success and overall survival of affected species.The release of high concentrations of toxic heavy metals into the marine environment poses an additional threat. These metals can have detrimental effects on the growth, maturation cycles, and spatial distribution of organisms in proximity to mining operations. The accumulation of these toxic substances within organisms can result in reduced reproductive success, physiological abnormalities, and population declines.[27] Furthermore, deep-sea mining activities can have devastating consequences for benthic flora and fauna. The re-deposition of suspended particles and tailings can bury these organisms, depriving them of essential resources such as light, oxygen, and nutrients. This burial can lead to their suffering and ultimately increase the risk of extinction, resulting in a significant loss of biodiversity[28].

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[24]UNITED NATIONS, *World Charter for Nature* (1982) *available at*: https://digitallibrary.un.org/record/39295?v=pdf (last visited Apr. 20, 2023).

[25]INTERNATIONAL UNION FOR CONSERVATION OF NATURE: ISSUES BRIEF, Deep Sea Mining (2022) *available at*: https://www.iucn.org/sites/default/files/2022-07/iucn-issues-brief_dsm_update_final.pdf (last visited Apr. 20, 2023).

[26]MONGABAY, *If marine noise pollution is bad, deep-sea mining could add to the cacophony* (Nov. 24, 2021) *available at*: https://news.mongabay.com/2021/11/if-marine-noise-pollution-is-bad-deep-sea-mining-could-add-to-the-cacophony/ (last visited Apr. 20, 2023).

[27]Philip Weaver *et. al*., HANDBOOK ON MARINE ENVIRONMENT PROTECTION: ENVIRONMENTAL RISKS OF DEEP-SEA MINING 215 (2018).

[28]Beth N. Orcutt *et. al*., *Impacts of deep-sea mining on microbial ecosystem services*, LXV L&O 1489 (2020).

Beyond the immediate impacts, deep-sea mining can disrupt the delicate balance of marine ecosystems on a larger scale. Changes in total organic carbon content and seawater-dissolved oxygen levels can have far-reaching effects, influencing the diversity, quantity, and biomass of species in adjacent water columns.[29] The resulting disruptions to species composition can potentially destabilize these intricate ecosystems. Moreover, the physical disturbance caused by deep-sea mining activities can have catastrophic effects on seafloor habitats.[30] Vegetation and animals with limited mobility, unable to escape the destructive machinery and dredging equipment, face immediate death. The destruction of these habitats not only contributes to the decline of vulnerable species but also disrupts the intricate ecological niches that are essential for the overall health and functioning of marine ecosystems.

Given the grave concerns associated with deep-sea mining, it is imperative to approach these activities with utmost caution and carefully evaluate their potential environmental consequences, which up until now have been negative. Protecting the fragile and already-stressed state of our oceans is of utmost importance, especially in the face of mounting challenges such as plastic pollution and rising temperatures. Preserving the rich biodiversity, maintaining the integrity of marine food chains, and safeguarding the overall health and stability of marine ecosystems are at stake. It is worth noting that on top of this, the global geological hazards, climate change effects, and ocean pollution resulting from deep-sea mining activities are still largely unknown and uncertain.[31] The potential consequences of these activities extend beyond their immediate biological impacts and require further investigation and understanding. Comprehensive research, monitoring, and risk assessments are necessary to gain insights into the potential consequences on global geological stability, climate change, and ocean pollution.[32] This will help inform decision-making processes, allowing for more informed choices that prioritize the long-term health of the deep-sea environment and its ecosystems.

IV

Current International Structures regulating Deep-Sea Mineral Mining

The establishment of the International Seabed Authority (ISA) *("The Authority")* in 1996 was a direct result of Part XI of the United Nations Convention on the Law of the Sea (UNCLOS) from 1982 and its Implementation Agreement in 1994. The primary objective

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[29] *Id.*

[30] Charles Roche *et. al.*, ANTICIPATING SOCIAL AND COMMUNITY IMPACTS OF DEEP SEA 59 (2013).

[31] Axel Hallgren *et. al.*, *Conflicting Narratives of Deep Sea Mining,* XIII Sustainability 5261 (2021).

[32] Aricò Salvatore *et. al.*, BIOPROSPECTING OF GENETIC RESOURCES IN THE DEEP SEABED: SCIENTIFIC, LEGAL AND POLICY ASPECTS (2005).

of the ISA is to organize and regulate activities in the Common Heritage of Humankind (*"The Area")*, which refers to the regions beyond national jurisdiction, particularly concerning the extraction of mineral resources.[33]Additionally, the ISA is responsible for safeguarding and conserving the natural resources within the Area, as well as preventing any harm to the marine environment's flora and fauna. This includes addressing the potentially detrimental effects of activities such as drilling, dredging, excavation, and waste disposal. These protective measures are necessary because the resources within the Area are considered the Common Heritage of Mankind, belonging to all of humanity, including future generations. Thus, the ISA assumes the role of a guardian for this shared heritage. To fulfill this role, the Authority has endeavored to implement necessary measures to ensure the effective protection of the marine environment from the adverse impacts of human activities, specifically deep-sea mining. One of these measures is the adoption of appropriate rules, regulations, and procedures by the ISA, which it has done in pursuance of Article 145 of the UNCLOS.[34]

The Authority has developed regulations, including provisions relating to environmental protection, to govern exploration. Till now, the approval has been granted for 31 exploration contracts in the Pacific, Indian, and Atlantic Oceans, encompassing a vast area of over 1.3 million square kilometers on the ocean floor. These contracts are held by States parties to UNCLOS and sponsored companies associated with those parties. The participation of various national governments, such as China, France, Germany, India, Japan, the Republic of Korea, the Russian Federation, and the Interocean metal Joint Organization (comprising Bulgaria, Cuba, the Czech Republic, Poland, the Russian Federation, and Slovakia), is evident. Currently, the Authority is dedicating its attention to the development of a regulatory framework for the exploitation of these resources. While a draft of the regulatory regime has been released, it remains to be finalized.

Nonetheless, the primary concern of the Authority, acting as a regulator, lies in finding a balance between the societal advantages of deep seabed mining (which include access to crucial minerals, non-displacement of communities, extensive deep-sea research, and technological progress) and the imperative of safeguarding the marine environment. The requirement for obtaining permission from the Authority before any form of exploitation takes place ensures that the environmental impacts of deep seabed mining are effectively monitored and controlled by an international entity.[35]This in itself reflects

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[33]Sarah E. Moffitt *et. al*., *Response of seafloor ecosystems to abrupt global climate change*, CXII PNAS 4684 (2015).

[34]Convention on the Law of the Sea, Dec. 10, 1982, 1833, U.N.T.S. 397, Art. 145.

[35]Joanna Dingwall, THE LAW OF THE SEABED: CHAPTER 7: COMMERCIAL MINING ACTIVITIES IN THE DEEP SEABED BEYOND NATIONAL JURISDICTION: THE INTERNATIONAL LEGAL FRAMEWORK 139 (2020).

a precautionary approach to seabed development, but the major predicament shows up when non-member states, like the US claim sovereignty over CHM resources and express their unilateral intent to mine the seabed without prior approval of the ISA. It is evident that mining impacts the marine environment to some extent, especially in the immediate vicinity of mining operations, so will the non member states like the US, not be bound by the regulations developed by the ISA? Will they be permitted to mine the Deep-Sea bed unilaterally?

Under the authority of the United Nations, the International Seabed Authority (ISA) has made significant progress in regulating deep seabed activities. In July 2000, the ISA approved the Regulations on Prospecting and Exploration for Polymetallic Nodules in the Area, effectively establishing itself as the primary governing body in this realm. Remarkably, even states not party to the United Nations Convention on the Law of the Sea (UNCLOS) or the ISA are obligated to adhere to these regulations. This obligation stems from the regulations' embodiment of customary international law, supported by widespread state practice and acknowledged opinio juris. These factors solidify the ISA's pivotal role and compel compliance with its regulations.

Uniform State Practice: For customary international law to develop, state practice must be both uniform and widespread. The ISA has mandated that no exploitation activities be conducted in the Area until it issues its exploitation regulations. Notably, all states have adhered to this mandate by refraining from engaging in any form of exploitation. Furthermore, all states interested in exploration and future exploitation have entered into contracts with the ISA, underscoring the high regard they hold for the ISA and its regulations. This consistent practice and extensive support from states demonstrate a unified commitment to upholding the ISA's authority and its role in governing the deep seabed.

Opinio Juris: Opinio juris refers to the belief among states that a particular treaty or legal framework represents a binding obligation. In a 2011 Advisory Opinion, the Seabed Disputes Chamber recognized the ISA as the sole body responsible for governing matters concerning the protection of the marine environment in the Area from exploitation. As the chamber is entrusted with resolving disputes related to UNCLOS interpretation, its acknowledgment of the ISA further reinforces the ISA's status as a customary norm. This recognition underscores the perception among states that the ISA and its regulations constitute a legal obligation in the international landscape.

Deep seabed mining (DSM), up until now, has not commenced in accordance with the ISA's mandate, as states await the adoption of the exploitation regulations. However, failure to seek permission from the ISA deviates from the general state practice. By neglecting to notify the ISA, the consideration of the marine environment's safety is

bypassed, thereby violating the principal objective of UNCLOS, which is marine preservation. Now that the ISA has emerged as the central governing body for deep seabed mining under the United Nations and in accordance with UNCLOS, through its regulations and with the support of states, it has successfully established customary international law that governs the exploration and exploitation of the deep seabed. The uniform state practice, as well as the recognition of the ISA's authority by the Seabed Disputes Chamber, reaffirms its pivotal role as a custodian of the marine environment. While awaiting the adoption of exploitation regulations, it is crucial for states to adhere to the ISA's mandate to ensure responsible and sustainable exploitation of deep seabed resources. By upholding the ISA's regulations, states contribute to the fulfillment of UNCLOS's objective of marine preservation and demonstrate their commitment to safeguarding the fragile ecosystems of the deep seabed.

V

India's Vision for Ocean Exploitation

On New Year's Day 2015, India's Science and Technology Minister Harsh Vardhan called on Indian scientists and officials to "grab" India's due share of ocean wealth. Delivered at the National Institute of Oceanography in Goa, the speech is one of the most succinct articulations of India's vision for the future of ocean exploitation.[36] He recognised the indispensable role of oceanic resources in addressing the challenges of the future including securing nutrition, employment, raw materials and most importantly economic growth to sustain a world population of nine billion.[37] However, realizing the strain of overexploitation, pollution, declining biodiversity and climate change on the oceans, he emphasized on using responsible and sustainable approaches to fully realize the potential of these resources.

Under its contract with the ISA, India was allotted an area of almost 75,000 square kilometres in the Central Indian Ocean Basin and another 10,000 square kilometers in the Mid-Ocean ridge. [38]The contract harbours great promise for the nation with preliminary reports by the Ministry of Earth Sciences[39] (MoES) indicating that the

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[36]THE ECONOMIC TIMES, *India should grab share in ocean-based industry: Harsh Vardhan* (Jan. 01, 2015) *available at*: https://economictimes.indiatimes.com/news/politics-and-nation/india-should-grab-share-in-ocean-based-industry-harsh-vardhan/articleshow/45718906.cms (last visited Apr. 20, 2023).

[37]*Id.*

[38]INTERNATIONAL SEABED AUTHORITY, *The Government of India Signs Exploration Contract with the International Seabed Authority* (Sept. 26, 2016) *available at*: https://www.isa.org.jm/news/government-india-signs-exploration-contract-international-seabed-authority/ (last visited Apr. 20,2023).

[39]Ministry of Earth Sciences, DEEP OCEAN MISSION (2021) *available at*: https://www.moes.gov.in/index.php/schemes/dom?language_content_entity=en (last visited Apr. 20, 2023).

Indian Ocean seabed contains at least 380 million metric tonnes of Polymetallic Nodules comprising Copper, Nickel, Cobalt & Manganese.[40] To provide perspective, the estimated value of these metals is close to $110 billion, a tenth of which could fuel India's energy requirements for the next hundred.[41]Recognising the incredible potential promised by the deep seabed frontier, India launched its flagship programme the Deep Ocean Mission. The mission has set out to explore and identify potential sites of multi-metal hydrothermal sulphide mineralization along the Indian Ocean mid-oceanic regions at a depth of 3000-4000 meters. Under the wing of the Deep Ocean Mission, operation Samudryaan[42] was launched ('Samudra' meaning Ocean and 'Yaan' meaning vehicle) to create India's first manned mission to reach the ocean bed at 6,000 meters below the water surface with its indigenously developed underwater vehicle (Matsya 6000) for deep-sea mining and exploration. With this step, India joined the elite club of nations including USA, Russia, Japan, France and China in developing such underwater vehicles for carrying out subsea activities.

However, the pursuit of ocean wealth through deep sea mining comes with inherent dangers and risks that must be addressed to ensure the sustainability and protection of marine ecosystems. India should exercise due caution and implement comprehensive safeguards before proceeding with deep sea mining operations. Primarily, engaging the current opaque mineral extraction regimes on interdisciplinary grounds by considering inputs from a range of voices- from marine scientists (biologists, ecologists, geologists, etc), social scientist (political economists, geographers, development scholars, etc.) and civil society actors (large NGOs, small fishing associations, cooperatives, etc.).[43]These differing opinions serve as a point for public engagement with a kind of ombudsman role, helping to pierce the opaque veil of governance that exists at present.[44] India should prioritize marine scientific research and environmental assessments to understand the potential impacts of deep sea mining on marine ecosystems and biodiversity. It is crucial to establish stringent regulations and international collaboration to prevent the irreversible destruction of delicate ecosystems and to mitigate any potential adverse effects on marine life. By incorporating best practices

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[40]PRESS INFORMATION BUREAU, *Union Minister Dr Jitendra Singh says, Deep Ocean Mission to be implemented by Ministry of Earth Sciences at a total budget of Rs. 4077 Cr for 5 years during the period 2021-2026* (Aug. 10, 2021) *available at*: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1744421 (last visited Apr. 20, 2023).

[41]*Id.*

[42]PRESS INFORMATION BUREAU, *Union Minister Dr. Jitendra Singh says, Samudrayaan Mission is aimed at sending three personnel to 6000-metre depth in a vehicle called 'MATSYA 6000' for the exploration of deep sea resources like minerals* (Dec. 21, 2022) *available at*: https://pib.gov.in/PressReleasePage.aspx?PRID=1885366 (last visited Apr. 20, 2023).

[43]Adam Jadhav, MINERALS FROM THE SEA 52 (2016).

[44]*Id.*

and adopting innovative technologies, India can strive for a balanced approach that harnesses the benefits of deep sea mining while ensuring the long-term health and resilience of our oceans.

VI

Conclusion

As the field of deep-sea mining progresses towards commercial viability, it is crucial to engage in a robust and comprehensive dialogue that surpasses the conventional discussions on stakeholder perceptions and social licensing. The development of exploitation regulations and the consideration of contracts for commercial mining necessitate an extensive recognition and deliberation on the challenges associated with achieving and verifying No Net Loss (NNL) through the mitigation hierarchy. In the event that mining activities are permitted, and losses are acknowledged, it becomes imperative for national governments, the International Seabed Authority (ISA), and deep-sea mining contractors to intensify their focus on the preventive measures outlined in the mitigation hierarchy, particularly avoidance and minimization. This approach should be underpinned by a precautionary and adaptive framework. Additionally, there is a need to conduct research both within and beyond mining areas, expanding our knowledge and capacity to better comprehend and safeguard deep-sea biodiversity, surpassing existing legal obligations. In order to ensure responsible mining practices, a staged approach to permitting the industry's development could be adopted. This approach entails exploiting sites with perceived lower risk, facilitating the development of mitigatory technologies, monitoring and testing predicted impacts. The insights gained from this phased strategy should inform the progression of the industry, with subsequent stages of exploitation contingent upon the successful ability to predict and mitigate impacts, as well as associated biodiversity loss.

The allocation of Rs 600 crore in the Union Budget 2023-2024 for the Deep Ocean Mission represents a significant milestone in India's unwavering pursuit of unlocking the immense potential of our oceanic resources. This increased funding serves as a testament to the government's firm commitment to explore marine biodiversity and ensure the sustainable utilization of our oceanic wealth. Undoubtedly, oceans play a multifaceted role, serving as repositories of food, energy, minerals, medicines, and key influencers of weather patterns and climate. The Deep Ocean Mission encompasses a diverse range of activities, including the development of a manned submersible, ship-building, deep-sea biodiversity conservation, and the identification of valuable mineral deposits in the profound depths of the ocean.

Deep-sea mining, a pivotal component of the mission, holds great promise in extracting critical metals such as cobalt, manganese, zinc, and others, which are indispensable for the production of batteries, renewable energy infrastructure, and advanced electronics. India's acquisition of a 15-year contract for mining polymetallic nodules in the Central Indian Ocean Basin stands as a testament to our commitment to secure a domestic supply of nickel and cobalt, vital ingredients for the global energy transition. While concerns have been raised by experts regarding the potential impact on deep-ocean biodiversity, it is imperative to address these concerns through rigorous scientific research. A comprehensive understanding of the biology, ecology, and connectivity of deep-sea species and ecosystems is crucial for ensuring responsible mining practices.

The Deep Ocean Mission has garnered international recognition and commendation, with the ISA acknowledging India's pioneering efforts in deep-sea mining. The seabed of the Indian Ocean holds vast quantities of critical minerals, including copper, nickel, cobalt, and manganese, which not only fulfill India's domestic demands but also contribute significantly to the global energy transition. By aligning its efforts with the United Nations Convention on the Law of the Sea, the Indian government, through the Deep Ocean Mission, is poised to effectively organize, regulate, and control mineral-related activities in the international seabed area, ultimately benefiting the entire humanity. As made evident, India has an unwavering commitment to harnessing the untapped potential of our oceans in a sustainable and responsible manner. By simultaneously exploring and conserving marine biodiversity and unlocking critical mineral resources, India can propel its development while actively contributing to a greener future. Through increased funding and technological advancements, India has a unique opportunity to shape the global landscape of deep-sea mineral exploration and establish itself as a leader in this field. The Deep Ocean Mission sets the stage for a future where our marine resources are harnessed for the benefit of humanity while ensuring the long-term health and preservation of our oceans. This mission not only presents a remarkable opportunity but also a significant responsibility to strike a balance between development and environmental conservation for the collective benefit of present and future generations.