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Navigating the Uncertainty: Financial, Technological, and Geopolitical Risks in Deep-Sea Mining Ventures.

Deep-sea mining (DSM) involves extracting minerals from ocean depths exceeding 200 meters, focusing on resources like hydrothermal vents, ferromanganese crusts, and polymetallic nodules [1]. These resources are rich in valuable metals like cobalt, nickel, rare earth elements, and manganese, which are essential for technologies like electric vehicle batteries and renewable energy systems. For instance, as depicted in Figure 1, the electric vehicle market is expected to expand rapidly, leading to an increased need for essential minerals.

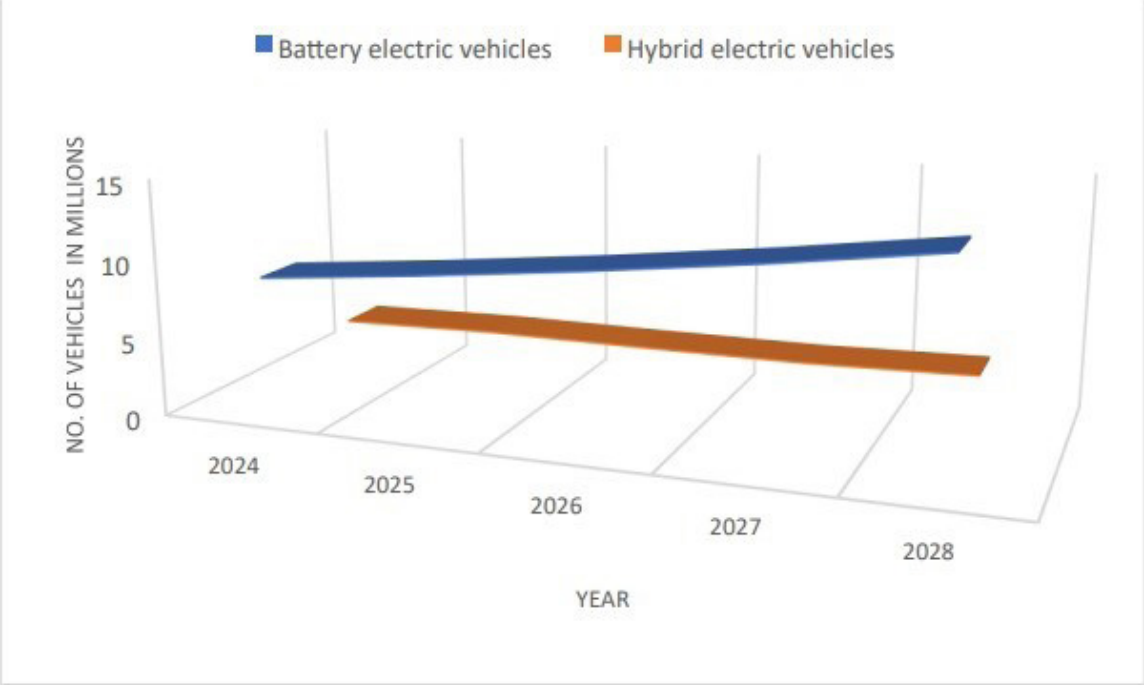

Figure 1: The Forecasted Electric Vehicle Demand [2]

While the DSM offers an exceptional opportunity to access the minerals, it also raises significant concerns about marine ecosystem degradation, biodiversity loss, and potential conflicts with other marine resource users [3]. The International Seabed Authority (ISA) is currently developing regulations to manage DSM, aiming to balance resource extraction with environmental protection.

The DSM offers both chances and problems as the need for important materials grows around the world accompanied by the expanding global population, and rising consumption levels. At the moment, there is a significant reliance on land-based mining to meet the mineral supply for fast-growing industries. Nevertheless, it is challenging due to some reasons: their finite availability on the land and sensitive environmental consciousness. Consequently, it is essential to explore alternative solutions, our oceans cover a significant portion of the Earth's surface, with DSM presenting an appealing possibility to solve the scarcity of land-based minerals. Furthermore, according to Figure 2, DSM offers access to abundant untapped resources on the ocean floor, surpassing the availability of resources from land-based mining activities. Amid the raised global demand for renewable energy minerals, the potential to exploit substantial resources in DSM is perceived by some as a supply and financial opportunity.

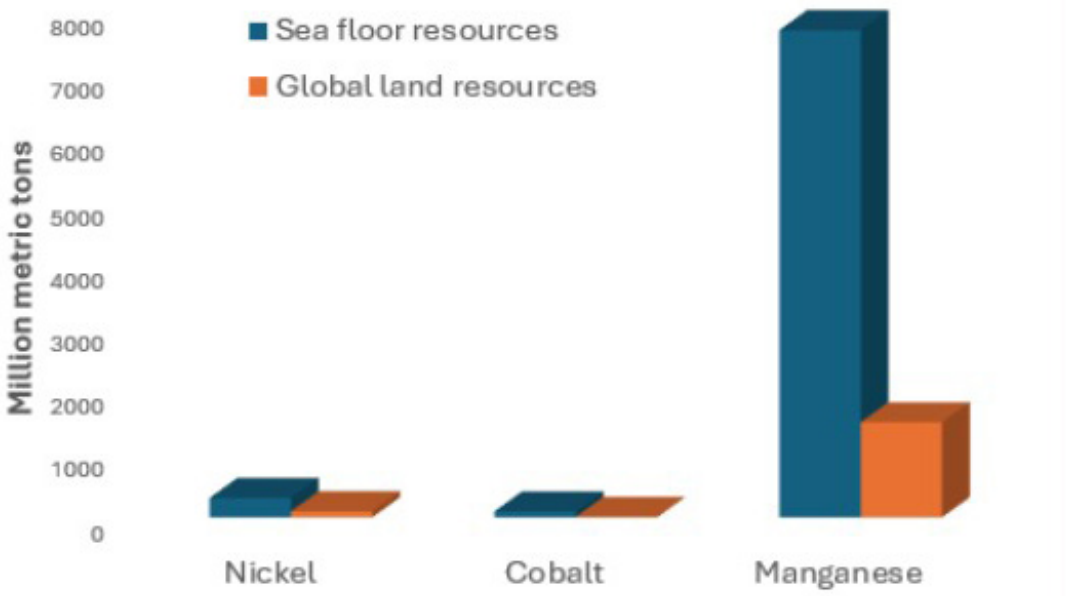

Figure 2 : A comparison of resource availability on land and seafloor [7]

To raise the growth of the DSM industry, it is essential to further explore its financial dimensions. This requires the development of tailored financial instruments, frameworks, reporting standards, and financing channels tailored specifically for DSM. Such tools are critical for managing the substantial initial investments in technology and infrastructure, accurately assessing risks, and ensuring the long-term financial viability of DSM operations. By carefully managing the financial aspects in the near future, it ensures a balanced approach to leveraging the economic advantages of DSM while mitigating its potential harm.

As the DSM industry is evolving, it not only offers a potential opportunity for mineral extraction but also facilitates substantial advancement of marine science and engineering through DSM leading to the creation of new job opportunities and the establishment of fresh businesses, contributing to economic growth. Countries such as Japan, South Korea, and Norway have already invested in DSM technology, motivated by potential economic gains and the need to secure essential resources. For instance, Japan's exploration in the Okinawa Trough has demonstrated the feasibility of extracting hydrothermal deposits. In the Clarion-Clipperton

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Zone in the Pacific, companies like DeepGreen Metals are pioneering the extraction of polymetallic nodules rich in cobalt and nickel, essential for electric vehicle batteries. These examples showcase that although DSM has high upfront costs, often exceeding USD 1 billion, the returns can be substantial. These advancements can positively impact the economies of nations involved in DSM [5]. As illustrated by India's exploration of the cobalt-rich Afanasy Nikitin Seamount and Sri Lanka's competing claims in the Indian Ocean, there is a possibility of geopolitical tensions emerging, potentially leading to legal or diplomatic disputes over resource ownership [6] despite the economic opportunity create to the country. As countries explore the potential economic and environmental benefits of DSM, it is crucial to approach these issues with care.

Potential investors have been reluctant to engage in the DSM industry due to the lack of literature on the financial elements of DSM investments and the lack of thorough examination of the risks and opportunities involved. Consequently, the research team from the Department of Industrial Management, Faculty of Business, University of Moratuwa aims to bridge this gap by addressing three key objectives which are to conduct a situational analysis of DSM investments, to identify the critical factors influencing financial investment in DSM, and to formulate policy recommendations to enhance the financial viability and sustainability of DSM investments. By fulfilling these objectives, the study will offer critical insights into the factors influencing investment decisions in DSM, thereby facilitating more informed and strategic decision-making.

As per the findings the team was classifying risk into six (06) categories which are the risk of continuity and supply chains, technological risk, social risk, market volatility risk, legal risk, and risk of finance and return. To find out the most critical factors, researchers will collect data using a structured questionnaire and collect data using the Delphi method. The developed questionnaire will be sent to twenty international industry experts who are interested in DSM expecting a minimum of nine (09) responses. Before that, researchers conducted a pilot study and gathered feedback to enhance the quality of the survey and eliminate the biases. In addition to this questionnaire, researchers aim to interview a minimum of two (02) industry experts to get a more in-depth understanding. Data will be analyzed using the Analytical Hierarchy Process (AHP). Based on the results, this research further will provide suggestions for policies that will improve the sustainability and financial performance of DSM investments.

In summary, DSM offers Sri Lanka a unique opportunity to access essential metal resources required for the global green economy. Due to its strategic position in the Indian Ocean and the increasing demand for metals such as nickel and cobalt, Sri Lanka has the potential to benefit economically and technologically from DSM. However, it is essential to carefully manage the financial and environmental risks associated with this endeavor.

By promoting innovation, establishing strong regulatory frameworks, and forming strategic alliances, Sri Lanka can capitalize on significant potential while upholding sustainability, thereby securing a leading position in the emerging DSM sector amid growing regional competition.

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