UPSC CIVILS EXAM

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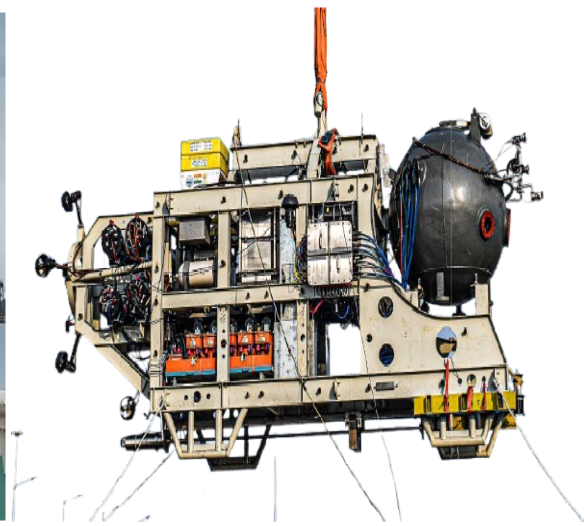
ARTICLE

DEEP OCEAN EXPLORATION MISSION OF INDIA

India’s Deep Ocean Exploration

India's Deep Ocean Exploration is being advanced through the Deep Ocean Mission, also known as the Samudrayaan program, which aims to explore and utilize the deep ocean resources in India's exclusive economic zone and continental shelf, focusing on depths up to 6,000 meters in the Indian Ocean. It includes developing indigenous technology like the manned submersible Matsya-6000, which can carry three people and endure extreme oceanic conditions. The mission's goals include exploring polymetallic nodules (rich in valuable minerals like manganese, nickel, cobalt, and copper), assessing living and non-living deep-sea resources, marine biodiversity, and supporting India's Blue Economy initiatives. India plans to launch the manned submersible for deep-sea exploration by 2026, and the program is likely to put India among few nations with such advanced underwater exploration capabilities.



Key points include:

- ✓ The Samudrayaan submersible is designed to dive to 6,000 meters, carrying 3 humans for up to 72 hours.
- ✓ India's allocated seabed area for exploration is 75,000 sq km in the Central Indian Ocean Basin, with estimated 380 million tonnes of polymetallic nodules.
- ✓ The Deep Ocean Mission is a multi-institutional, multi-ministerial project under the Ministry of Earth Sciences, with an estimated budget of about ₹4,077 crore for five years (2021-2026).
- ✓ The mission focuses on technology development, environmental sustainability, resource exploration, and oceanographic research.
- ✓ Successful wet trials of the Matsya-6000 submersible have already been conducted, leading up to deeper ocean descents planned by 2026.

- ✓ This mission aligns with global sustainable development goals and positions India as the sixth country to send a manned submersible to such ocean depths. It also emphasizes indigenous technological development and the potential economic and environmental benefits of deep ocean resource utilization.

Significance of India's Deep Ocean Mission

- ✓ **Boosts blue economy**: The DOM supports the Government of India's "Blue Economy" initiatives, promoting sustainable use of ocean resources for economic growth and livelihood opportunities.
- ✓ **Secures strategic resources**: India has been allotted a 75,000 sq km site in the Central Indian Ocean Basin by the UN International Sea Bed Authority for the exploration of polymetallic nodules. These resources are crucial for India's industrial and energy needs.
- ✓ **Enhances national security**: Developing advanced deep-sea capabilities, including surveillance and defense technology, is vital to protect India's underwater infrastructure and maritime borders, especially in the context of increasing geopolitical competition.
- ✓ **Advances scientific and technological capabilities**: The mission drives indigenous technology development across various fields, including marine engineering, robotics, and biotechnology, reducing reliance on foreign expertise.
- ✓ **Addresses climate change**: Research conducted as part of the DOM contributes to a better understanding of the ocean's role in regulating climate and mitigating the impacts of climate change.

What are the main technological challenges India faces in deep-sea exploration

The main technological challenges India faces in deep-sea exploration include:

- ✓ **Extreme underwater pressure**: At depths around 6,000 meters, pressure exceeds 600 times surface pressure (over 60 MPa), requiring specially designed materials like titanium alloys and very robust submersibles to withstand crushing forces without failure. This demands precision engineering and sophisticated design, as seen in the Matsya-6000 submersible development.
- ✓ **Communication difficulties underwater**: Electromagnetic waves do not propagate well underwater, severely limiting communication capabilities with remotely operated vehicles (ROVs). Advanced acoustic communication systems such as Very Low Frequency (VLF) and Extremely Low Frequency (ELF) sound waves are required but are technologically complex and expensive to develop.
- ✓ **Lack of adequate infrastructure and skilled manpower**: India currently lacks sufficient research vessels, underwater robotics, oceanographic equipment, and trained specialists in deep-sea robotics and submersible operation, which slows progress. Institutes are still developing capacity to meet these demands.
- ✓ **High financial cost and investment requirement**: Development of deep-sea technologies including submersibles, autonomous underwater vehicles (AUVs), and

mining systems requires large, sustained investment. The Matsya-6000 alone costs around ₹350 crore. The long gestation period for returns adds to cost-benefit concerns.

- ✓ **Environmental and engineering challenges**: Operating in deep oceans involves complex engineering solutions to deal with poor visibility (natural light penetrates only a few meters), corrosion from seawater, soft muddy seabeds that complicate vehicle landing, and the need for energy-intensive extraction methods for minerals like polymetallic nodules.
- ✓ **Geopolitical and security risks**: Competition with countries like China, as well as threats of sabotage or spying (such as deep-sea cable-cutting devices), pose strategic challenges affecting access and security in deep-sea zones.

In summary, India's technological challenges in deep-sea exploration center on engineering for extreme pressure and harsh conditions, developing underwater communication, building infrastructure and skills, securing investments, managing environmental impact, and navigating geopolitical pressures. These require focused advances under missions like the Deep Ocean Mission to enable India's capabilities in this strategic frontier

Why are high costs a major obstacle for India's deep-sea exploration plans?

- ✓ High costs are a major obstacle for India's deep-sea exploration plans primarily because developing the required advanced technologies and infrastructure demands heavy and sustained financial investment. For example, the Matsya-6000 submersible alone costs around ₹350 crore. Building specialized vessels, autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), deep-sea drilling technology, and communication systems involves multi-billion-dollar investments. This is compounded by the need for expensive, high-quality materials like titanium alloys to withstand extreme pressures at depths of around 6,000 meters, along with the costs of research, skilled manpower development, and long project gestation periods without immediate returns.
- ✓ Further, India currently lacks adequate research vessels, sophisticated underwater robotics, and oceanographic equipment, necessitating additional expenditure to build these capabilities. Environmental regulations require careful impact assessments, increasing operational complexity and costs. Compared to countries like China, the US, and Russia that have invested heavily over decades, India's relative infancy in this domain means higher per-unit costs due to lack of economies of scale and mature infrastructure.

- ✓ These financial challenges slow down the pace of technological development and exploration activities, making it difficult for India to quickly advance in deep-sea exploration, which is strategically and economically important for resource extraction, scientific knowledge, and national security.

In summary, the high upfront and ongoing costs for technology development, infrastructure build-up, skilled workforce training, and operational risk management form a significant barrier preventing India from rapidly scaling its deep-sea exploration capabilities.

How does India's deep ocean mission compare to other countries' efforts?

India’s Deep Ocean Mission (DOM) places the country in an elite group of nations actively developing crewed deep-sea exploration capabilities and advanced ocean resource technologies, comparable to powers like the USA, China, Russia, Japan, and France.

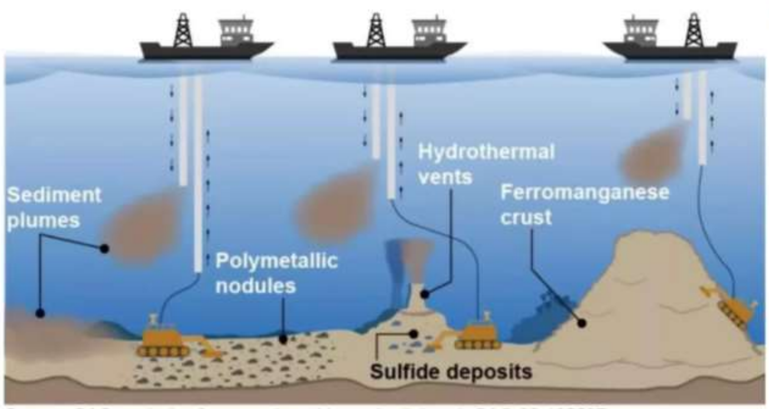
Key points of comparison are:

- ✓ **Technological Capability:** India’s DOM aims to develop indigenous underwater technology such as the Matsya-6000, a manned submersible designed to reach depths of 6,000 meters. This achievement aligns India with countries like China (Jiaolong submersible), the USA, Russia, and Japan, which possess similar deep-sea submersibles and autonomous underwater vehicles. India’s emphasis on technological sovereignty parallels models like ISRO’s approach to space technology.
- ✓ **Economic Focus**: Like other leading countries, India’s mission targets exploring polymetallic nodules, deep-sea biodiversity, and energy resources with an eye on expanding the “Blue Economy,” which India projects could add $1 trillion to GDP by 2047. This economic rationale mirrors efforts by countries such as the USA and China, who see deep-sea resource extraction as a strategic economic frontier.
- ✓ **Strategic and Geopolitical Importance**: India’s DOM is also positioned as a tool for maritime security, regional influence in the Indian Ocean Region (IOR), and supporting initiatives like the SAGAR doctrine. This aspect is crucial in a global context where countries compete for undersea territory and resources, particularly in geopolitically sensitive zones.
- ✓ **Research and Environmental Goals**: Beyond resource extraction, India places a pronounced emphasis on understanding the marine ecosystem, hydrothermal vents, and climate change impact on oceans, aligning with global scientific and sustainable development goals—similar to programs in more developed oceanographic nations.
- ✓ **Budget and Scale**: The budget of about ₹4,077 crore over five years (2021-2026) to develop deep ocean technology and infrastructure is substantial for India though

remains modest compared to decades of investment by countries like the USA, Russia, and China with wider-ranging deep-sea assets and longer histories of deep-sea exploration.

In summary, India's Deep Ocean Mission is a carefully crafted, indigenous technological and scientific effort that brings it alongside the major global players in deep ocean exploration. While India is newer to the field and developing its capabilities, the strategic economic, technological, and environmental framework of DOM is broadly comparable to the focused, multi-dimensional efforts seen in countries with more mature deep-sea programs.

What potential resources could India access through the Samudrayaan program?



Source: GAO analysis of peer reviewed journal articles. | GAO-22-105507

Through the Samudrayaan program, India could access several valuable deep-sea resources, primarily:

- ✓ **Polymetallic nodules**: These are rich in manganese, nickel, cobalt, copper, and iron. Just 10% of these nodules have the potential to meet India's energy requirements for the next century, making them strategically important for electronics, batteries, and renewable energy technologies.
- ✓ **Cobalt crusts and hydrothermal sulfides**: These contain cobalt and other rare earth minerals essential for advanced technology and clean energy applications.
- ✓ **Gas hydrates**: Methane clathrates found in deep seabeds are potential energy resources that the mission aims to assess.
- ✓ **Marine biodiversity resources**: The mission also focuses on assessing deep-sea living resources, which can support sustainable marine biotech and fisheries.

- ✓ Other minerals and energy resources: The mission includes exploration for resources like nickel and rare earth elements critical for India's technological and energy security.

Samudrayaan's objective is to explore these resources responsibly while supporting India's Blue Economy and enhancing scientific understanding of the deep ocean. Access to these resources could greatly contribute to India's energy security, economic growth, and technological independence in the coming decades