MARITIME RESEARCH CENTER
FOUNDATION FOR UNDERWATER DOMAIN AWARENESS

Research Note

E-Learning Module – 2

Tropical Waters and Unique Characteristics: Anthropogenic Perspective of the Indian Ocean

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Introduction

Today, the Indian Ocean (IO) is important because it is a crucial route for world trade, especially in energy. Its extensive and heavily populated littoral includes some of the world's fastest-growing areas. Around 800 CE, ocean shipping for foreign trade began. This made it easier for people in Africa, India, and China to trade goods they wanted with each other. This led to the growth of a trade network in the Indian Ocean, which let economic giants like the Persian Empire and the Caliphates of Turkey do much business. The Indian Ocean Trade Route was one of history's most important trade routes. It connected the Middle East, East Asia, India, and Africa.[1]

As trade technology in the Indian Ocean improved, so did business and ties between countries. People may have traded in the Indian Ocean as early as 1500 BC. Over time, Portuguese sailors found light boats specifically made for ocean trade. For example, the long and thin Dhow could carry many goods. At the same time, the Chinese improved their ships so they could sail the seas and trade.[2]

The IO is ideally placed at the global trade hub, connecting the major economic hubs in the Asia-Pacific and the North Atlantic. This means that the amount of business shipping has grown by almost four times since 1970. India's cultural impact has grown thanks to the Ocean, which has brought people, religion, goods, and customs to India from Africa, the Middle East, and Southeast Asia. About two billion people live in the Ocean's huge drainage basin. This significantly creates chances for working together since the economies along the Indian Ocean rim are proliferating.

[1] Indian Ocean Trade | Route, History & Impact. Retrieved From: https://study.com/academy/lesson/indian-ocean-trade-route-network-history.html
[2] Indian Ocean Trade | Route, History & Impact. Retrieved From: https://study.com/academy/lesson/indian-ocean-trade-route-network-history.html

With 48 of Asia's 63 ports, the IO is the third-largest body of water in the world. The area also has sizeable offshore hydrocarbon sources that have yet to be used. These are important for meeting Asia's growing energy needs. Ensuring the region is stable is essential for the prosperity of the area and the world. With 45% of the world's wars, 75% of its natural disasters, and 40% of its people, the Indian Ocean Region (IOR) is a centre of attention.[3]

The ocean is a great place to find fishing and mineral riches. India is the most populous country in the area and a strategic keystone, so the Indian Ocean basin is significant to them. The IO has dramatically changed because of new technologies that have opened up its economic and strategic possibilities. As the world's population has grown and developed, people's actions have greatly affected this large body of water. This study note talks about the IO's unique social and economic potential, focusing on how its different physical and chemical properties make it different in terms of how acoustic waves travel.

Trade and Shipping

Over 80% of the world's oil trade by sea goes through the Indian Ocean's choke points, making its sea lanes very important globally. 40% of them go through the Strait of Hormuz, 35% go through Malacca, and 8% go through the Bab el-Mandab Strait[4]. The IOR is home to the world's most important waterways and trade lanes. It handles 61% of all container traffic and 70% of all petroleum product traffic. Every year, almost 100,000 ships pass through these seas[5]. In the past, Europeans were motivated by ancient sailors to cross the Indian Ocean to get to the East and bring back goods like silks, rugs, tea, and spices. The IO is also critical for moving oil from Southeast Asia to the West.[6]

Since the middle of the 20th century, especially after becoming independent, the IO's coastal countries have all made different economic progress. Regional trade blocs have made it easier to trade by sea and have created new goods. With a few exceptions, like Australia, India, and South Africa, most IO states still export raw materials and receive finished goods. The IO is essential for getting crude oil to Europe, North America, and East Asia, so it plays a significant role in trade. Iron, coal, rubber, and tea are some other important goods. Japan gets iron ore from Western Australia, India, and South Africa. Going the other way, Australia sends coal to the UK through the Indian Ocean. For coastal states, processed fish is now one of their main exports, and tourism has become important on many islands.[7]

According to 2014 data, the countries around the IO made up 10% of the world's GDP, just under US$78 trillion. In the early 21st century, the long-term normal was about 6–7%. This was more than that. The rest of the world is more productive than the Indian Ocean region, even though the Indian Ocean region's output is essential. The IO is home to important marine

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[3] Venkatshamy, K. (2016). The Indian Ocean Region in India's strategic futures: looking out to 2030. In *Power, Politics and Maritime Governance in the Indian Ocean* (pp. 17-41). Routledge.
[4] Why the Indian Ocean Matters. Retrieved From: Why the Indian Ocean Matters – The Diplomat
[5] Venkatshamy, K. (2016). The Indian Ocean Region in India's strategic futures: looking out to 2030. In *Power, Politics and Maritime Governance in the Indian Ocean* (pp. 17-41). Routledge.
[6] Indian Ocean. Retrieved From: https://web.archive.org/web/20010802084832/http://oceanographer.navy.mil/indian.html
[7] Indian Ocean. Retrieved From: https://www.britannica.com/place/Indian-Ocean/Trade-and-transportation

chokepoints, which are narrow channels on global trade routes that can cause navigation mistakes, collisions, and other problems that could have economic and environmental effects. Some of these places are also vulnerable to piracy because valuable goods are close to land, which makes them appealing to pirates in smaller boats.[8]

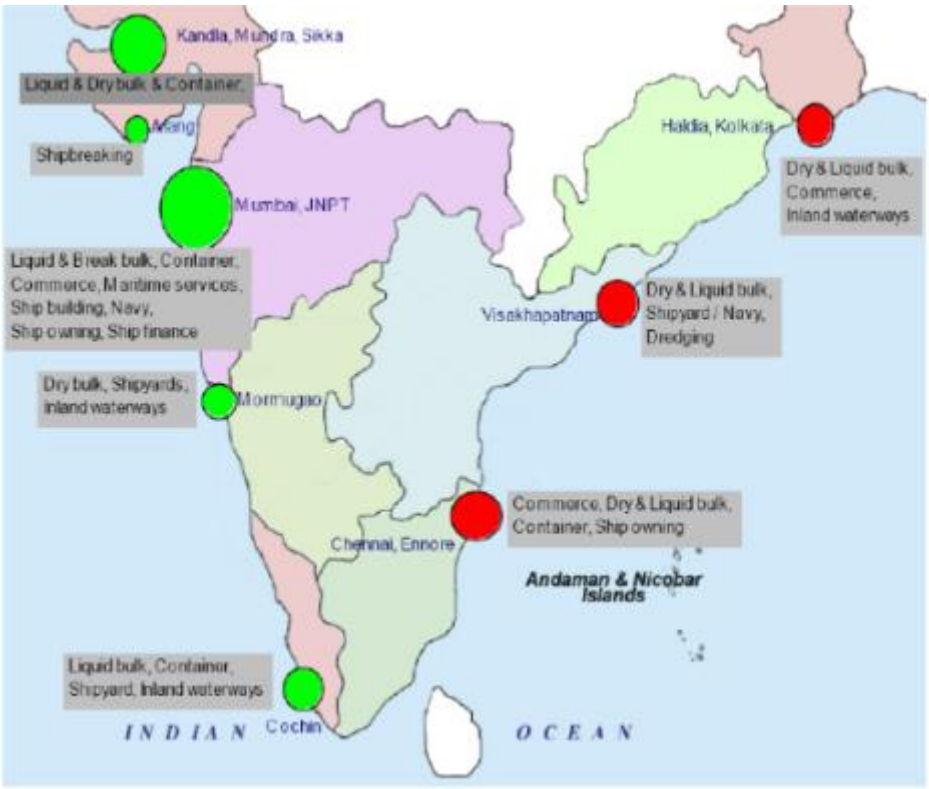

Figure 1: Activity-wise distribution of major Indian ports.[9]

Shipping is a big part of India's transportation system when it comes to the Indian country. Maritime transport is used for about 95% of the country's trade amount (70% by value). India has a strategic advantage because it has a long coastline of 7,500 km, with 12 big ports and 187 minor ports. Because of its location, India has much potential to become a hub for trade and transhipment.[10] India has been actively increasing its strategic influence by becoming a major foreign investor in the area's mining, oil, gas, and infrastructure projects. This is done by using its "soft power." This strategy helps the littoral states, which depend on marine resources for food and money to export.

[8] Llewellyn, L. E., English, S., & Barnwell, S. (2016). A roadmap to a sustainable Indian Ocean blue economy. *Journal of the Indian Ocean Region*, *12*(1), 52-66.

[9] Dasgupta, S. (2018). Indian Shipping Industry-an ocean of opportunities. In *55th National Maritime Day celebration Conference at IMU (Indian Maritime University–formerly DMET Kolkata) Campus in Kolkata*.

[10] Dasgupta, S. (2018). Indian Shipping Industry-an ocean of opportunities. In *55th National Maritime Day celebration Conference at IMU (Indian Maritime University–formerly DMET Kolkata) Campus in Kolkata*.

Oil and Gas:

Approximately 40% of the world's offshore oil production is attributed to the IO. The IO is responsible for about 40% of offshore oil production. Large amounts of hydrocarbons can be found in the waters around India, Iran, Saudi Arabia, and western Australia. About 65% of the world's oil stocks are in ten littoral states along the IO. Big oil companies have started doing upstream activities in the East African littoral because of new gas discoveries off the coast of Tanzania in 2010 and growing hopes that it will become a critical oil frontier, especially for exporting liquid natural gas (LNG) to Asia.[11] [12]

Petroleum is the most expensive mineral in the IO. The Persian Gulf is where most of the world's oil is produced. Offshore oil and gas, thought to have ample supplies, are being looked for in the Arabian Sea and the Bay of Bengal. There are also explorations going on off the northwest coast of Australia, in the Andaman Sea, off the coast of Africa south of the Equator, and on the coast of Madagascar in the southwest. India, along with the countries in the Persian Gulf, is a major oil producer from distant areas, especially from fields off the coast of Mumbai. Natural gas is also produced off the northwest coast of Australia. [13]

Polymetallic Nodules

The IOR has many valuable things, like oil and natural gas, and important materials like iron, manganese, nickel, and gold. There are also polymetallic nodules (PMNs) and special high-tonnage mineral sources with manganese, nickel, and cobalt. It might be possible to make money from these potato-sized concretions, mainly if they are used in improved energy batteries. However, because PMNs are found in environmentally sensitive and remote places, they can't be taken out without special equipment. This is India's Polymetallic Nodule project, a big research and development project that aims to use these nonliving things for economic and social growth. It makes India one of the eight countries with a long-term programme to explore and use polymetallic nodules.[14]

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[11] Venkatshamy, K. (2016). The Indian Ocean Region in India's strategic futures: looking out to 2030. In *Power, Politics and Maritime Governance in the Indian Ocean* (pp. 17-41). Routledge.
[12] Bouchard, C., & Crumplin, W. (2010). Neglected no longer: the Indian Ocean at the forefront of world geopolitics and global geostrategy. *Journal of the Indian Ocean Region*, *6*(1), 26-51.
[13] Indian Ocean. Retrieved From: https://www.britannica.com/place/Indian-Ocean/Trade-and-transportation
[14] Romit Rajendra Kaware. Research Note, Abiotic Element Detection - Technological Interventions in The Indian Littoral Waters. Maritime Research Center, Pune.

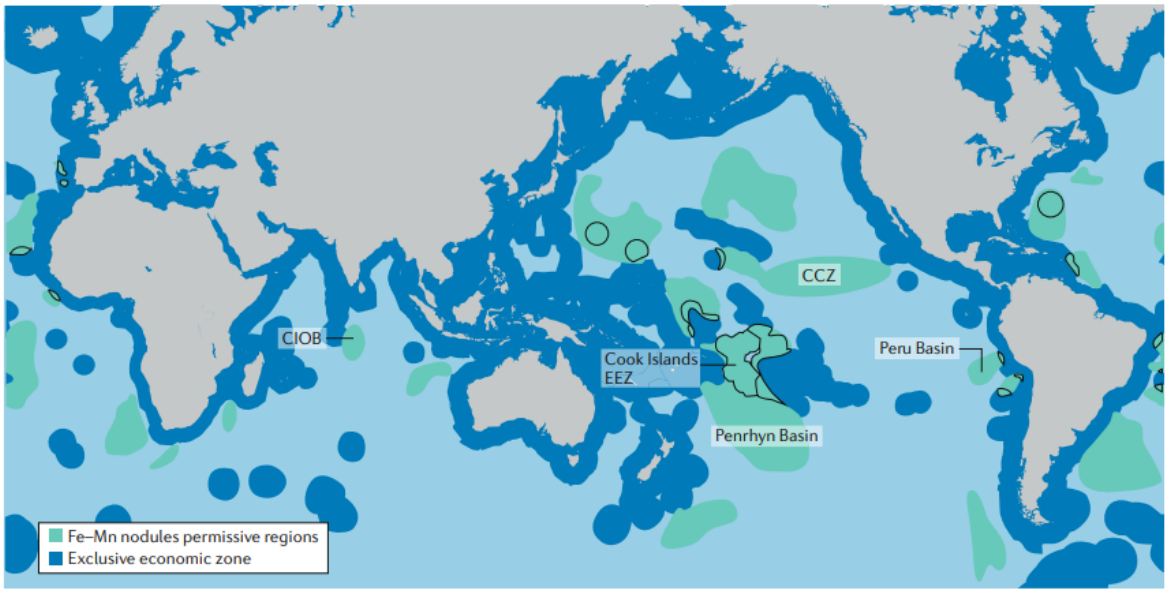

Figure 2: Global permissive areas for deep-ocean polymetallic nodule deposits. [15]

Nodules that are economically sound can be found in the Clarion-Clipperton Zone (CCZ) in the central Indian Ocean Basin and the Pacific Ocean near the equator. These bumps cover 9 million km2 in the CCZ, and the amounts are usually around 15 kg m-2. Nickel, copper, cobalt, and small amounts of molybdenum, rare earth elements, and lithium are found in these nodules. These metals are significant for high-tech businesses. In the Indian Ocean, there are a lot of manganese nodules. The manganese content is most significant in the east and lowest in the northwest. In nearshore sand banks, you can also find ilmenite, tin, monazite (rare earth), zircon, and chromite, all minerals that could be used for business purposes.[16]

It is known that oceanic polymetallic deposits could be a key source of important minerals, such as rare earth elements (REE), ferrous and non-ferrous metals, and more. This group of sulphide and oxide material deposits has a lot of Ni, Cu, Co, Ag, Au, Mn, Mo, Zn, and REE, which makes them very important for industry. It's important to note that the amounts of metals found in ocean layers, especially Ni, Co, Cu, and Ag, are about the same as those found on land. Notably, the amount of copper in nodules from the Clarion-Clipperton Zone (CCZ) is thought to be about 20% of the amount found in all land-based sources around the world. The high economic value of these oceanic deposits comes from having large amounts of strategic metals, higher metal concentrations than land deposits, and a lot of overall prognostic resources.[17]

Polymetallic nodules have much value and promise beyond the quality of their ore. People know these clusters work well as sorbents to clean gases and as building blocks for making inorganic ion exchange materials. The materials made from these nodules could be used instead

[15] Hein, J. R., Koschinsky, A., & Kuhn, T. (2020). Deep-ocean polymetallic nodules as a resource for critical materials. *Nature Reviews Earth & Environment*, *1*(3), 158-169.
[16] Indian Ocean. Retrieved From: https://www.britannica.com/place/Indian-Ocean/Trade-and-transportation
[17] Kotlin'Ski, R. A., Maciag, L., & Zawadzki, D. (2015). Potential and recent problems of the possible polymetallic sources in the oceanic deposits. *Геология и полезные ископаемые мирового океана*, (2 (40)), 65-80.

of synthetic bitumens in processes that remove water, clean up industrial trash, and recover metals at a lower cost.[18]

Marine Trash

The IO differs from other ocean basins because it has unique landforms, weather, and marine conditions that affect how buoyant plastics move. The eastern border of Africa links the southern IO and the South Atlantic Ocean in the southern IO. This makes it possible for plastics to be moved and for garbage to be traded. How the atmosphere moves is important for how the floating plastics in the IO move.[19]

Plastic trash in the IO has yet to get as much study and attention as in other oceans, and little is known about what happens to plastics. However, the IO receives a lot of plastic from the oceans worldwide. It's thought to get up to 15% of plastic from the coast and 20% from rivers[20]. Half of the world's plastic waste is found along the IO, where big rivers like the Ganges and the Indus flow into the ocean. The IO is thought to have the second-heaviest plastic load in the world after the North Pacific Ocean.[21]

The study by Woodall et al. (2014)[22] looked at sand core samples from the southwest IO that were 500 to 1000 metres deep. Based on what they found, this area has about 4 billion threads per square kilometre[23]. Plastics tend to sink to the bottom, as shown by the fact that deep-sea animals in the IO eat them. Much water from homes and factories flows into the Indian coastal seas yearly—about 3.9x10^12 litres of the former and 3.9x10^11 litres of the latter. Many pollution and changes that can't be stopped in coastal areas across many countries harm biodiversity.[24]

Eriksen and his team found the trash patch in the Indian Ocean in 2010[25]. It is about halfway between Africa and Australia. The trash patches in the Pacific and Atlantic seas have been studied much more than in the Indian Ocean, which is more mysterious because it is in a more

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[18] Kotlin'Ski, R. A., Maciag, L., & Zawadzki, D. (2015). Potential and recent problems of the possible polymetallic sources in the oceanic deposits. *Геология и полезные ископаемые мирового океана*, (2 (40)), 65-80.

[19] Pattiaratchi, C. B., van der Mheen, M., Schlundt, C., Narayanaswamy, B., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean–sources, transport, distribution and impacts. *Ocean science*, *18*, 1-28.

[20] Thiemann, T. (2023). Microplastic in the Marine Environment of the Indian Ocean. *Journal of Environmental Protection*, *14*(4), 297-359.

[21] Pattiaratchi, C. B., van der Mheen, M., Schlundt, C., Narayanaswamy, B., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean–sources, transport, distribution and impacts. *Ocean science*, *18*, 1-28.

[22] Woodall, L. C., Sanchez-Vidal, A., Canals, M., Paterson, G. L., Coppock, R., Sleight, V., ... & Thompson, R. C. (2014). The deep sea is a major sink for microplastic debris. *Royal Society open science*, *1*(4), 140317.

[23] Pattiaratchi, C. B., van der Mheen, M., Schlundt, C., Narayanaswamy, B., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean–sources, transport, distribution and impacts. *Ocean science*, *18*, 1-28.

[24] Wafar, M., Venkataraman, K., Ingole, B., Ajmal Khan, S., & LokaBharathi, P. (2011). State of knowledge of coastal and marine biodiversity of Indian Ocean countries. *PLoS one*, *6*(1), e14613.

[25] Plane Search Shows World's Oceans Are Full of Trash. Retrieved From: https://web.archive.org/web/20140407080032/http://news.nationalgeographic.com/news/

remote area. Eriksen and his team set sail from Perth, Australia, west towards Africa to make notes about this area.[26]

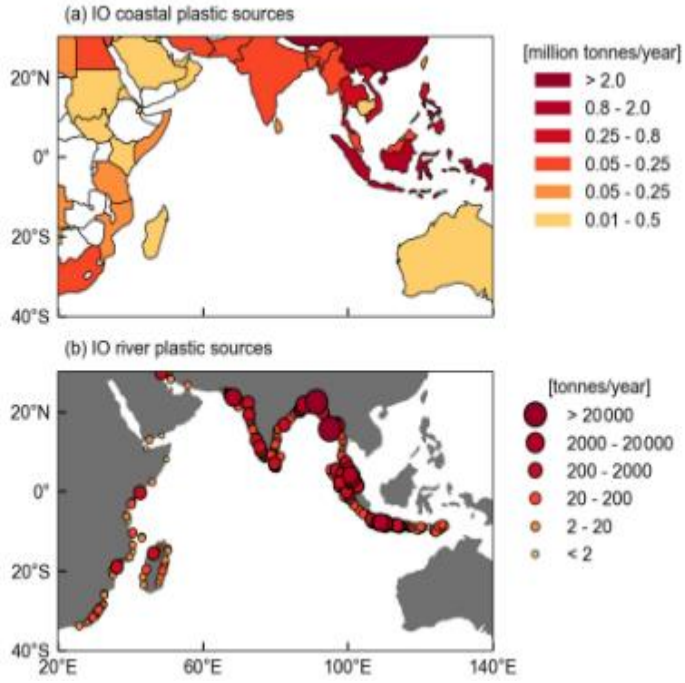

Figure 3: a) Estimated coastal sources of plastic waste entering the Indian Ocean; b) Estimated river sources of plastic waste entering the Indian Ocean. [27]

Pollution from putting trash in the ocean and oil spills are some of the problems that the marine environment is facing right now. Deep-sea mining is becoming a bigger problem, and the Arabian, Persian, and Red Seas are significantly affected by oil waste. Coral reefs are in danger because of climate change, direct human impacts, and a lack of political will, knowledge, and governance. The loss of biodiversity is a serious problem, and coastal species like dugongs, seals, turtles, and whales are in grave danger.[28]

Moving big amounts of crude oil across the ocean and nearby partially enclosed seas is another problem. Phytoplankton and zooplankton are essential parts of the food chain for commercial

[26] New garbage patch discovered in Indian Ocean. Retrieved From: https://web.archive.org/web/20111002012819/http://green.yahoo.com/blog/greenpicks/286/new-garbage-patch-discovered-in-indian-ocean.html

[27] Pattiaratchi, C. B., van der Mheen, M., Schlundt, C., Narayanaswamy, B., Sura, A., Hajbane, S., ... & Wijeratne, S. (2022). Plastics in the Indian Ocean–sources, transport, distribution and impacts. *Ocean science*, *18*, 1-28.

[28] The World Factbook Indian Ocean. Retrieved From: https://www.cia.gov/the-world-factbook/oceans/indian-ocean/

fisheries. Still, oil spills from normal tanker operations and odd major tanker accidents have hurt them.[29]

Diverse Cultural Scenario

The IOR is a mix of cultures that have grown over hundreds of years of interactions between the many groups living along its shores. The area includes East Africa, Southeast Asia, and Australia. It is a mix of different faiths, languages, and ethnic groups. There are thousands of ethnic groups, tribes, and clans in this large ethnocultural mosaic, as well as many different languages and faiths. These racial and cultural differences have caused trouble and are often very important in national politics.[30]

Significant differences exist in the socioeconomic growth of the IOR's states, with many people living in poverty and needing more work. There is a big difference between the wealthiest countries and the poorest ones. For example, Australia's Human Development Index (HDI) score of 0.970 in 2007 put it in second place, while Afghanistan's score of 0.352 put it in 181st place. The Indian Ocean Region's HDI score was 0.621, lower than the world's average of 0.753. Only six states in the area had a high human development index value of 0.900 or more, while 25 states had an HDI value of less than 0.600. As a result, problems with development are still very important in the area.[31]

Coastal communities in the western Indian Ocean are some of the poorest in the world. They have to deal with problems like low levels of schooling and being outside their own countries because they don't have official rights to critical marine resources. Because they depend on marine activities for a living, they damage habitats by overfishing, polluting, and building on the coast in ways that aren't sustainable. Recent extreme heat events have worsened these problems, likely worsening as the population grows and climate changes.[32] [33] This has made a social-ecological trap[34] where poor communities relying on natural resources run out of overharvest and damage the environment. Biological systems are becoming less able to recover, which makes them even more vulnerable. This shows how important it is to find long-term answers right away.

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[29] Indian Ocean. Retrieved From: https://www.britannica.com/place/Indian-Ocean/Trade-and-transportation

[30] Bouchard, C., & Crumplin, W. (2010). Neglected no longer: the Indian Ocean at the forefront of world geopolitics and global geostrategy. *Journal of the Indian Ocean Region*, *6*(1), 26-51.

[31] Bouchard, C., & Crumplin, W. (2010). Neglected no longer: the Indian Ocean at the forefront of world geopolitics and global geostrategy. *Journal of the Indian Ocean Region*, *6*(1), 26-51.

[32] McClanahan, T. R., Cinner, J. E., Maina, J., Graham, N. A. J., Daw, T. M., Stead, S. M., ... & Polunin, N. V. C. (2008). Conservation action in a changing climate. *Conservation letters*, *1*(2), 53-59.

[33] Cinner, J. E., McClanahan, T. R., MacNeil, M. A., Graham, N. A., Daw, T. M., Mukminin, A., ... & Kuange, J. (2012). Comanagement of coral reef social-ecological systems. *Proceedings of the National Academy of Sciences*, *109*(14), 5219-5222.

[34] Ateweberhan, M., Hudson, J., Rougier, A., Jiddawi, N. S., Msuya, F. E., Stead, S. M., & Harris, A. (2018). Community based aquaculture in the western Indian Ocean: challenges and opportunities for developing sustainable coastal livelihoods. *Ecology and Society*, *23*(4).

Way Ahead

Human activities in the Indian Ocean, mainly linked to sediment management, pose dual challenges and opportunities for the region's environmental sustainability. The escalation of urbanisation, industrialisation, and agriculture have increased sedimentation in coastal areas and marine ecosystems.

- Implementing effective technologies to minimise environmental damage.
- Conducting thorough baseline studies to evaluate the effects of human activities on the marine environment and its dynamics.
- Enforcing international regulations to curb over-exploitation and excessive use of marine resources.
- Assessing the impact of economic activities on distinctive environmental conditions.