Impacts of warming of Indian Ocean

Why in news?

A new study published in journal Science Direct has said that Indian Ocean is experiencing unprecedented and accelerated warming, which may continue throughout the century unless greenhouse gases (GHGs) are reduced immediately.

What are the key highlights of the study?

- **Rapid warming**-The study has predicted that between 2020 and 2100, the Indian Ocean could warm at a rate of 1.7-3.8°C increase per century if greenhouse gas emissions are not reduced.

  The future increase in heat content is equivalent to adding the energy of one Hiroshima atomic bomb detonation every second, all day, every day, for a decade.

- **Ocean basin heat**-The study examined the Indian Ocean's warming over the past century, finding that the ocean basin heated at a rate of 1.2°C per century between 1950 and 2020.
- **Expansion of Indian Ocean Warm Pool**- The study found that the area of the IOWP characterized by Sea Surface Temperature values exceeding 28°C, has expanded notably, particularly in the south-central basin.
- **Variability in Net Primary Production**- NPP exhibited large interannual variability in northern and central regions of Indian Ocean, while some northern regions shows slightly decreasing trends in NPP.

  Net Primary Production represents the net amount of energy that is stored by primary producers and made available to the rest of the ecosystem for growth and consumption.

- **Decline in chlorophyll**- The productivity and surface levels of chlorophyll are also expected to decline by 2100, with the greatest reduction in the western Arabian Sea, where levels could fall by 8-10% from their current state.
- **Temporal patterns**-

Temporal patterns	
Time period	**Key finding**
1998-2008	This period have cooler temperatures and higher productivity with few exceptions.
2009-2019	This period saw warmer temperatures and lower productivity
2017-19	This period showed increased productivity, particularly during the northeast monsoon period in the north-western regions.

- **Changes in Indian Ocean Dipole (IOD)-** The study predicts an increase in the frequency of extreme IOD events by 66%, while the frequency of moderate events is projected to decrease by 52% by the end of the century. These changes could further exacerbate the variability in monsoon rainfall patterns and impact regional climate dynamics.

Phases of IOD	About
Positive phase	• The western parts of the Indian Ocean are warmer than the eastern parts. • This leads to increased monsoon rainfall across many regions in India and South Asia.
Negative phase	• The western parts of the ocean are cooler than the eastern parts. • This can lead to below-normal rainfall during the post-monsoon period in north-western India.
Neutral phase	• Water flows from the Pacific between Indonesia's islands, keeping seas warm to the northwest of Australia. • This has very less impact on Indian monsoon.

- **Increase in heat content**-The current rate of increase in heat content within the first 2,000 meters below the ocean surface is 4.5 zettajoules per decade. However, future projections suggest a substantial rise to 16-22 zettajoules per decade.
- **Vulnerability-** The north-western parts of the Indian Ocean, including the Arabian Sea, experienced the most significant warming, while the south-eastern parts of the ocean, off the coasts of Sumatra and Java, experienced the least warming.
- **Change in pH level-** The bio-geochemical characteristics of the Indian Ocean are also expected to change due to the warming, for instance the pH levels of the ocean's waters are projected to decrease from about 8.1 currently to 7.7 by the end of the century.

What are the impacts of warming of Indian Ocean?

- **Monsoon changes**- The southwest monsoon, crucial for India's rainfall, could be affected by the increased heat content in the ocean's surface and subsurface layers.
- **Extreme weather events**- *Heavy rainfall* events and *extremely severe cyclones* have already become more frequent since the 1950s and are projected to increase further with rising ocean temperatures.
- **Sea level rise**- Thermal expansion of seawater contributes significantly to rising sea levels, which could lead to coastal erosion, flooding, and displacement of populations in the 40 countries bordering the Indian Ocean.
- **Changes in marine ecosystem**- The warming of the Indian Ocean is expected to

disrupt marine ecosystems, leading to coral bleaching, loss of biodiversity, and habitat destruction.

- **Acidification-** The projected changes in pH may be detrimental to the marine ecosystem since many marine organisms particularly corals and organisms that depend on calcification to build and maintain their shells as they are sensitive to the change in ocean acidity.
- **Decline in productivity-** Decline in chlorophyll levels could further affect marine productivity and food chains.
- **Marine heatwaves**- The frequency and intensity of marine heatwaves are expected to rise that could cause severe cyclones, they also lead to habitat destruction through coral bleaching, seagrass loss and the degradation of kelp forests, adversely affecting the fisheries sector and also

What lies ahead?

- The study underscores the urgency of reducing greenhouse gas emissions to mitigate the impacts of ocean warming.
- The findings emphasizes the importance of building climate-resilient infrastructure, conserving marine ecosystems, and enhancing forecasting capabilities to adapt to the changing conditions.

Reference

Down To Earth- Indian Ocean is heating up faster