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GUEST EDITORIAL

The impact of global warming on the oceans

Oceans cover 72% of the Earth's surface. They help sustain life and provide food and livelihood to a substantial portion of the global population. They are a vital part of Earth's climate system since they control the energy budget, carbon and nutrient cycles and slow down the impacts of global warming. Therefore, it is imperative that modifications in ocean temperature, chemistry, or constitution would have dire consequences for life, livelihood and sustainability.

The IPCC (Intergovernmental Panel on Climate Change) of the United Nations, a body for assessing the science related to climate change, has documented that the ocean has warmed unabated since 2005. At the ocean surface, temperature has, on an average, increased by 0.88°C from 1850–1900 to 2011–2020. Notably, 0.60°C of this warming has occurred only in the last four decades (since 1980). According to the IPCC climate change projections, by the 2050s, the ocean surface temperatures are projected to increase by about 1.5°C above the value in 1850. Not just the ocean surface, warming would also affect the deeper layers.

This unprecedented and unabated ocean warming is worrisome because even a slight increase in ocean temperature represents an enormous amount of energy capable enough to damage marine biodiversity, alter ocean chemistry, raise sea level and fuel extreme weather. For instance, ocean warming will adversely impact marine life. This loss of ocean biodiversity will threaten the livelihood of local communities, especially those that are exclusively dependent upon natural resources. Fisheries and food production could significantly decline. In tropical and temperate regions, the local coastal communities would be the worst hit, because the fish species would migrate north to find cooler temperatures and food sources. Also, warmer ocean temperatures would mean more oxygen-depleted ocean dead zones in large ocean basins rendering huge areas in the ocean uninhabitable for life forms. There is already a growing consensus that the open ocean is losing oxygen with about 0.5–3.3% between 1970 and 2010 from the ocean surface to a depth of 1000 metres. Since 1970, the oxygen minimum zones have been expanding by 3–8%, most noted in the tropical oceans. The latest Global Assessment Report on Biodiversity and Ecosystem Services documents that 66% of the global ocean is impacted by human activities, causing a sharp decline in the richness and abundance of ocean biodiversity. Studies also suggest that ocean warming has already affected fish catches and their composition in several geographic locations, changing primary production on growth, reproduction and survival of fish stocks. In addition to food production, ocean warming would equally hit the tourism sector as nearly 80% of all tourism is based close to the sea. For example, the destruction of coral reefs is already affecting coral reef-based tourism and recreation in several countries.

Ocean warming will also impact weather systems around the world. Tropical Cyclone (TC), the most important severe weather system, is influenced by ocean warming. An increasing trend in sea surface temperatures and ocean heat content could cause tropical cyclones to intensify quickly and travel longer distances without losing appreciable energy. Studies suggest a 6% per decade increase in major TC exceedance probability of 50. There is also evidence that TC intensification rates and the frequency of rapid intensification events have increased within this satellite era. The climate change projections suggest that average peak TC wind speeds and the proportion of very severe TC and average TC rain rates will elevate. The locations where TC reaches peak wind intensity will migrate poleward as the tropics expand with warming. The Indian Ocean is also warming quickly; a trend which is likely to continue. A warmer Indian Ocean would cause more intense precipitation events over India during the monsoon seasons, as it will promote more moisture advection and convergence.

Warmer oceans would also mean more frequent Marine Heatwaves (MHW), which are periods of extreme high sea surface temperatures. Unlike atmospheric heatwaves, MHW can extend for millions of square kilometres and persist for weeks to months. The most common drivers of MHW include ocean currents which can build up areas of warm water and air–sea heat flux or warm through the ocean surface from the atmosphere. From 1925 to 2016, global average marine heatwave frequency and duration increased by 34% and 17% respectively, resulting in a 54% increase in annual MHW days globally. The IPCC climate change projections suggest that MHW will become four times more frequent by 2080 than the 1995–2011 threshold. MHW can lead to severe and persistent impacts on marine ecosystems, coral bleaching, phytoplankton blooms, species composition

changes and toxic algal blooms. MHW would have profound socioeconomic impacts on coastal communities in fisheries, aquaculture and ecotourism industries.

Higher global temperatures will delay ice growth in the fall and winter and cause faster melting of sea ice in the succeeding spring exposing dark ocean waters for a longer period of time in the following summer. The major impact on sea ice will be seen over the Arctic Ocean. Arctic sea ice has declined significantly in all months since 1979, with maximum decline in September. The last fifteen September months have witnessed the maximum loss of Arctic Sea ice. It is projected that the Arctic Ocean may become sea ice-free during September for the first time before 2050 if warming continues. Loss of sea ice could disrupt ocean circulation, causing irreversible changes to the global climate. Arctic ice sheet loss has already been identified as one of the Climate Tipping Points. Studies suggest that the Atlantic Meridional Overturning Circulation (AMOC) is losing its stability. The AMOC decline is not just a response to global warming, but likely means approaching a critical threshold beyond which the circulation system could collapse.

Global warming will also cause sea levels to rise due to thermal expansion, mass loss from glaciers and ice sheets and changes in land-water storage patterns. It is certain that the global mean sea level will continue to rise through the 2050s. Compared to 1995–2014, the global mean sea level will rise by 0.18–0.23 metres by 2050. This rise could reach 0.38–0.77 metres by 2100. Rising sea level would mean loss of land, opportunity and livelihood for several communities.

Warmer oceans will absorb more atmospheric carbon dioxide (CO_2), causing higher ocean acidification. The rate of ocean uptake of atmospheric CO_2 has strengthened in the past two decades. The pH of the ocean is now about 8.1, which has been declining since the late 1980s, quite sharply by about 0.017–0.027 pH units per decade. The pH value could drop to 7.8 by 2100 if atmospheric CO_2 increases. Higher ocean acidification will harm several life forms such as corals and shellfish by dissolving their shells and exoskeletons made of calcium carbonate.

Elevated global temperatures and warmer oceans would alter several ecosystems across the globe. For instance, coastal ecosystems were already shrinking and stressed due to warming and sea-level rise exacerbated by non-climatic pressures arising from human activities. The last 50 years have witnessed warming-related mangrove encroachment into the sub-tropical salt marshes. Global wetland area has shrunken by nearly 50% since the pre-industrial era. Harmful algal blooms and pathogenic marine organisms have increased since the 1980s due to warming, deoxygenation and eutrophication. All such changes to the ecosystems will adversely impact food provisioning, tourism, economy and human health.

More effective ocean governance is the need of the hour for designing suitable adaptation responses and timely mitigation of adverse impacts of ocean warming. There are three major risks to oceans that arise from governance-related issues: (1) overexploitation of marine resources, (2) inequitable distribution of access to and benefits from marine ecosystem services, and (3) inadequate or inappropriate adaptation to changing ocean conditions. Reducing governance-related risks require stakeholders to co-create and implement ocean management plans and decision-making processes that are better, integrated and more comprehensive.

Most importantly, adherence to targets set by the Paris Agreement on Climate Change, especially holding the global average temperature rise below 2°C relative to the pre-industrial levels, is very urgent. Governments must strengthen cooperation on adaptive measures such as establishing marine-protected areas, setting precautionary catch limits, eliminating subsidies to prevent overfishing, and limiting coastal flooding and erosion by delineating coastal setback zones. Increased investments in scientific research and capacity building are required to improve the overall understanding of ocean variability and provide high-precision data on ocean warming and its impacts. Such investments should be concerted in areas such as improving monitoring of ocean warming and its effects, developing better ocean circulation models and innovative tools for observation and predicting ocean state and studying marine heat waves.

The United Nations' (UN) 2030 Agenda for Sustainable Development, adopted by all Member States, including India, lays down a shared blueprint for peace and prosperity for people and the planet. It lists 17 Sustainable Development Goals (SDGs) that constitute an urgent call for action by all countries. SDG-14 pertains to conserving and sustainably using the ocean, sea and marine resources. Moreover, the UN has proclaimed 2021–2030 as the Decade of Ocean Science for Sustainable Development. This highlights the need to support and bring together ocean stakeholders from across the globe to a common framework for the sustainable development of oceans. India remains an active member participating in both these initiatives. The Deep Ocean Mission, recently launched by the Ministry of Earth Sciences, and the Blue Economy Policy brought out by the Government of India will help the country achieve some of these targets.

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