

Risk-based adaptation to ease tropical cyclone impacts

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Cyclone Mocha — the first storm of 2023 in the North Indian Ocean — killed people, destroyed buildings, and caused economic losses in Myanmar, Bangladesh, Eastern India, and Sri Lanka. Barely a month later, Biparjoy — a rare June cyclone — formed over the Arabian Sea and struck Gujarat and other western states in India.

Cyclones occur every year, and those occurring in tropical oceans, such as the Indian Ocean, are known as tropical cyclones. Because of powerful winds and intense precipitation, tropical cyclones often cause extensive devastation, including coastal flooding.

Tropical cyclones in the Indian Ocean

The Indian Ocean, which encompasses the Bay of Bengal (BoB) and Arabian Sea basins, experiences two major periods of tropical cyclone activity, with the peak in November, followed by May. Among the parts of the Indian Ocean, the frequency of tropical cyclones has been five times higher in the BoB than in the Arabian Sea. Further, the deadliest cyclones with the highest catastrophe and fatality rates have occurred in the BoB, followed by the Arabian.

Impacts

An estimated 32 crore people or one-third of the Indian population may be at risk of cyclone impacts, as per an assessment by the National Disaster Management Authority (NDMA). Recurring cyclones are responsible for numerous fatalities, lost livelihood opportunities, and infrastructure damage, thereby derailing developmental progress over time. For instance, the 2020 Cyclone Amphan destroyed public infrastructure worth INR 1 lakh crore (equivalent to USD 13.46 billion) and around 1 million households, apart from causing 72 deaths in India. The total economic damage from cyclones in India has increased significantly from 0.22% in 1999 to 0.54% in [2020](#), in terms of gross domestic product.

Tropical cyclones and climate change

According to the *IPCC Special Report on The Ocean and Cryosphere in a Changing Climate*, human-induced climate change has increased precipitation and extreme sea level events associated with tropical cyclones. This, in turn, has increased the intensity and frequency of such weather events, thereby increasing the risk to coastal regions. Moreover, the rapid intensification of these cyclones presents difficulties in forecasting cyclones.

Adaptation measures for tropical cyclones

The devastating impacts of tropical cyclones and changing climate call for timely and appropriate adaptation strategies, including accurate cyclonic activity prediction, early warning systems, and inclusive disaster risk assessments. The following are some of the targeted strategies to buffer the damage and losses from tropical cyclones:

· Predicting consistently and accurately cyclonic activity 7 days in advance is crucial for improving the responses to cyclones, such as planning evacuation measures. However, reliable predictions are limited by the absence of prediction equations or models (given the changing nature of cyclones), the lack of observation data for models, and the unstable nature of the atmosphere. The use of artificial intelligence technologies could be explored to overcome some of these limitations, leading to improved predictions.

- *Deepening our understanding of the compounding and cascading risk factors for extreme storm surges and the resulting coastal flooding is needed for buffering the adverse impacts of cyclones.*
- *Performing spatial analysis to quantify varying levels of risk across regions is required to aid the development of location-specific adaptation strategies.*
- *Employing a combination of adaptation measures, such as 'hard' and 'soft' measures, to prevent damage caused by tropical cyclones is needed. While the former includes flood protection structures (sea walls and levees) and ecosystem-based measures (preserving mangroves and coral reefs), the latter encompasses the construction of disaster-resistant buildings and employing beach nourishment programmes and coastal early warning systems.*
- *Preparing a basket of adaptation strategies with a clear understanding of the feasibility of these measures under different levels of risks and regions is urgently needed.*
- *Providing financial protection schemes, such as catastrophe risk insurance, to aid communities in managing the adverse impacts of tropical cyclones is desirable.*

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