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Climate Change Vulnerability and Risk Assessment: Focusing on Coastal India

Ms. Sneh Gangwar

Assistant Professor, Aditi Mahavidyalaya, University of Delhi.

Abstract

The coastal region of India is inhabited by more than a 100 million people in nine coastal states, two union territories and two groups of islands. According to the census 2001, were about 65 coastal districts in these nine states. Climate change is posing great risks on India's densely populated and rich resource coastal zones. Past research on the climate change in India focuses on sea level rise based on the gradual erosion of the shoreline, and human adaptation. Sea level rise, changes in storms and wave climate as a consequence of climate change are expected to increase the size and magnitude of flooded and eroding coastal areas, thus having profound impacts on coastal communities, resources and ecosystems. River deltas, beaches, estuaries and lagoons are considered particularly vulnerable to the adverse effects of climate change, which need to be studied and focused on. The objective of this paper is to presents vulnerability assessment of coastal vulnerability to the envisaged effects of climate change, and provides vulnerability maps that allow prioritizing more vulnerable areas and targets of different climate-related impacts in coastal areas of India and support to assists coastal communities in coastal management and conservation.

Keywords: climate change, coastal areas, vulnerability, coastal resources, management, conservation.

1. Introduction

Climate change is recognized as a significant man-made global environmental challenge. It is also treated as a threat. Consequently, there is now a growing

recognition of the vulnerability of key sectors of economy and development due to climate change. The various assessment reports brought out since 1990s by the Intergovernmental Panel on Climate Change (IPCC) have progressively tracked the development and build up of knowledge and understanding of the science, impacts and mitigation of climate change at the global and regional levels. The IPCC has concluded that the impact of human activities on climate is unequivocal (IPCC, 2007). The debate at this point is on the extent and magnitude of climate change.

The Fourth Assessment Report of the IPCC provides the latest understanding regarding climate change at the continental level but the details at the regional and sub-regional levels are rather inadequate. The assessment emphasizes the need for more comprehensive studies and information at such levels. Wide-ranging implications and adverse impacts due to climate change have been projected on developing countries. As a part of India's Initial National Communication to the UNFCCC, impacts of climate change on water resources, agriculture, natural ecosystems and forestry, human health, infrastructure and energy were assessed and reported for the 2050s and 2080s.

2. Assess Vulnerability

The assessment of vulnerability focuses on gaining an understanding of how climate variability and change will impact coastal communities, the goods and services provided by natural resources, and human-built infrastructure. Vulnerability assessment for climate change in specific coastal regions considers three factors: 1) the nature and magnitude of climate variability and change; 2) the human, capital, and natural assets that will be exposed to and impacted by climate change; and 3) the current capacity of coastal communities and ecosystems to adapt to and cope with climate impacts. Climate is changing in response to increased greenhouse gas emissions, and projections for the coming decades paint a sombre picture. There is scientific consensus that increases in greenhouse gases in the atmosphere drive warming temperatures of air and sea, and that the world's oceans acidify as they absorb the carbon dioxide warming of air and sea causes shifts in precipitation patterns and hydrological cycles, sea level rise, and more frequent and severe extreme weather events (e.g., storms and storm surge). These effects are already being witnessed in the India's coastal regions and are projected to intensify in years to come. According to scientists, the rising temperature of the earths surface would spell down for the planet in the long run. The consequences of global warming on the coastal zones are one of the major concerns among scientists. Rise in sea levels, a direct impact of global warming and climate change is the key factor threatening the coastal areas of the world and India. The coastal zones of the India are mostly populated because of reasons like fertile soil, opportunity for the development of fishing and shipping industry and so on. Global warming and the subsequent rise in sea levels would cause frequent floods in the coastal zones. The effects of global warming would be first felt on these coastal zones.

3. Key Features about the Climate Change in Coastal Region

- In the eastern coast, the rainfall is likely to range between 858±85.8mm to 1280± 204.8mm in the 2030s. The increase in the 2030s with respect to the 1970s is estimated to range between 0.2% to 4.4%. Projections for the western coast indicate a variation from 935±185.33mm to 1794±247mm, which is an increase of 6%–8% with respect to the1970s.
- In the eastern coastal region, the mean annual air temperature is likely to rise from 28.7± 0.6oC to 29.3±0.7oC. The rise in temperature with respect to the 1970s is around 1.6oC to 2.1oC. In the western coastal region, mean annual temperatures are likely to increase to 26.8±0.4oC to 27.5±0.4oC in the 2030s. The rise in temperature with respect to the 1970s will be between 1.7oC and 1.8oC.
- The rise in minimum temperatures along the eastern coastal regions is likely to be lower than in the western coastal region. The change in minimum temperatures along the eastern costal region is projected to range from 2.0oC to 4.5oC, the higher end of the change being limited to Tamil Nadu. The change in maximum temperature in the 2030s with respect to 1970s ranges between 1oC and 3.5oC.
- The western coast experiences similar extremes in temperature as the Western Ghats. In the eastern coast, the numbers of rainy days are likely to decrease by 1–5 days, with a slight increase along the Orissa coast. The intensity of rainfall is likely to increase between 1mm/day and 4mm/day.
- Since 1986, a decreasing frequency in cyclones along the eastern coast surrounded by the Bay of
- Bengal and the northern Indian Ocean have been observed. Also, no trend is seen in the western coast for the same period which is along the Arabian Sea. The projected number of cyclonic disturbances along both the coasts in the 2030s is estimated to decrease with respect to the 1970s. However, cyclonic systems might be more intense in the future.
- Storm surge1 return periods could only be estimated at a 100 year time scale. It is found that all locations along the eastern coast of India, that are north of Visakhapatnam, except Sagar and Kolkata, show an increase in 100-year return periods of storm surges by 15% to 20 % with respect to the 1970s.

Observations based on tide gauge measurements along the Indian coast, for a period of 20 years and more for which significantly consistent data is available indicate that the sea level along the Indian coast has been rising at the rate of about 1.3mm/year on an average. In the absence of the availability of regional projections, for the 2030s, global projections can be used as a first approximation of sea-level rise along the Indian coasts in the next few decades.

Climate change will exacerbate environmental and social problems in the coastal areas of the Indian Ocean basin. In Southeast Asia, climate change poses a grave threat to agriculture and food security, water resources, natural ecosystems, forestry,

biodiversity, and human health. Throughout the region, rising sea levels constitute the most serious risk for coastal nations, with Bangladesh, India, Indonesia, the Maldives, Myanmar, the Philippines, Tanzania, and Vietnam figuring among the most vulnerable. The LDCs, particularly the small island developing states (SIDS), will disproportionately bear the brunt of climate change impacts. They contribute little to world greenhouse gas emissions, yet they possess limited capacity to mitigate the impacts of global warming and face other natural hazards as well. Rising not more than 3 meters above sea level, the Maldives faces the grim prospect of being completely submerged by rapidly rising seas within the century.

Table 1: Major Threats to Coastal Environment due to Climate Change in India.

SECTOR	CLIMATE CHANGE THREAT	OTHER HUMAN THREATS
CORAL REEF AND COASTAL ECOSYSTEM	-Loss of coral reefs from coral bleaching -Loss or Migration of coastal ecosystem -Coastal erosion and sedimentation -Change in the distribution of marine species -Increased spread of exotic and invasive species	-Intense coastal development and habitat loss -Pollution and marine dead zones -Conversion of mangroves and wetland for mariculture -Damage to sea grass beds -Coral mining and oil spills -Spread of invasive species
FISHERIES	-Overall decline in ocean productivity -Eutrophication and coral mortality -Loss of shift in critical fish habitat -Temperature shift causing migration of fishes -Extreme events, temperature increase and oxygen depletion -Ocean acidification	-Over harvesting -Destructive fishing practices -Land based source of pollution -Sedimentation of coastal system from land based sources
MARICULTURE	-Increase in water temperature could result in unpredictable changes in cultural productivity -Increase stress and Vulnerability to pathogens -Changes in weather pattern and extreme weather events	-Overexploitation of juveniles and larvae seed stock for fish farm -Loss of protective habitats from improper sitting for mariculture facilities

RECREATION AND TOURISM	-Storms, erosion and precipitation damaging infrastructure and causing losses to beaches -Compromised water quality and increasing beach closures -Increases in tourism insurance costs	-Improper sitting of tourist facilities -Alteration of the shoreline, coastal processes and habitat -Strain on freshwater resources for tourist facilities -Marine pollution and habitat disruption from recreational boating
FRESHWATER RESOURCE	-Saltwater intrusion of freshwater sources -Encroachment of saltwater into estuaries and coastal rivers -Waves and storm surges reaching further inland, increasing coastal inundation and flooding -Decreased precipitation, enhancing saltwater intrusion, and exacerbating water supply problem	-Discharge of untreated sewage and chemical contamination of coastal water -Unregulated freshwater extraction and withdrawal of groundwater -Upstream dams -Enlargement and dredging of waterways
HUMAN SETTLEMENT	-Coastal inundation -Infrastructure damage -Sea level rise during storm surge -Reduced clearance under bridges -Overtopping of coastal defence structure -Degradation of natural coastal region	-Inappropriate sitting of infrastructure -Habitat conservation and biodiversity loss

Source: IPCC Report, 2007

4. Risk and Impact Analysis

The productivity of irrigated rice is likely to reduce by 4% in most of the areas in this region. However, irrigated rice in parts of southern Karnataka and northern-most districts of Kerala is likely to gain. In case of rain-fed rice, all areas in the region are likely to lose yields by upto 10%. The results thus indicate that irrigated rice is able to benefit due to CO2 fertilization effect as compared to the rain-fed rice, which is supplied with less amount of fertilizers.

Figure 2: Relative vulnerability of coastal deltas shown by the indicative population potentially displaced by current sea level trends to 2050.
Index: (Extreme=>1 million; High= 1 million to 50,000; Medium= 50,000 to 5000)

Climate change is likely to reduce yields of maize and sorghum by up to 50% depending upon area in this region. These crops have C4 photosynthetic systems and hence do not have relative advantage at higher CO2 concentrations. Coconut yields are projected to increase as much as 30% in the majority of the region by the 2030s. Increase in coconut yield may be mainly attributed to the projected increase in rainfall (~10%) and relatively less increase in temperatures, apart from CO2 fertilization benefits. However, some areas like south-west Karnataka, parts of Tamil Nadu and parts of Maharashtra may show reduction in yields up to 24%.

The Temperature Humidity Index (THI), an index used to define losses due to thermal stress is highest in the months of September–April and is likely to remain under highly stressful conditions in the 2030s. The livestock in the

Coastal regions are likely to be highly vulnerable with consequent adverse impacts on its productivity throughout the year in the 2030 scenario with THI above 80. An increase in recruitment and catches of oil sardine during the post-southwest monsoon season along the coastal region, especially along the Kerala coast, is expected in the future due to warming, elevated Sea Surface Temperature (SST), favourable wind (and perhaps current) and increasing Coastal Upwelling Index (CUI) inducing higher chlorophyll concentration during the southwest.

A qualitative assessment indicates that morbidity and mortality of the population in the regions under focus are likely to increase with warming temperatures and variable precipitation as they have direct as well as indirect effects. Direct effects can manifest as heat stress and indirect effects can be in terms of vector borne diseases, water borne diseases and malnutrition etc. Malaria transmission in coastal areas, particularly the east coast, is projected to experience reduction in the number of months open for transmission. The number of times it is open for in 10–12 months may reduce by 34%.

In conclusion it can be said that coastal region of India is highly vulnerable by extreme events and climate change risk, which need to focus for sustainable development and adaptation.