Inspira- Journal of Modern Management & Entrepreneurship (JMME)
ISSN : 2231–167X, General Impact Factor : 2.3982, Volume 07, No. 04, October, 2017, pp. 183-188

ADAPTATION OPTIONS IN COASTAL ZONE AREAS MANAGEMENT IN THE FACE OF CLIMATE CHANGE IN INDIA

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ABSTRACT

The impact of climate change on coastal areas is going to be a serious concern for the central and state governments in India. India with seas on three sides has a vast coastline with heavy density of population mainly consisting of poor and marginalized coastal communities. The enormity of the problem is discussed along with adaptation techniques at the ground level in order for coastal communities to deal with their daily livelihood issues.

KEYWORDS: *Adaptation, Climate Change, Coastal Zones, Coral Reefs, Mangroves, Mitigation, Sea Grasses.*

Introduction

Management of coastal zones is particularly crucial in India. India"s coastline is 7,525 kilometres long, 20% to 25% of the population lives within 50 kilometres of the coast, and 70% of that total in rural areas (ADB 2010). The Indian coastal zone is inhabited by more than 100 million people in nine coastal states. The east coast comprises West Bengal, Orissa, Andhra Pradesh, Tamil Nadu; the west coast comprises Kerala, Karnataka, Goa, Maharashtra and Gujarat. There are two coastal union territories (Pondicherry, Daman and Diu), and two groups of islands (Andaman and Nicobars, Lakshadweep).

The most visible impacts of climate change are being witnessed in coastal zones. Coastal areas the world over are witnessing severe damage along the coastline from salinization, strong coastal storms, heavy rain, strong winds, and associated storm surges and inundation that have increased manifold. The most recent is the damage in Texas, USA which has seen the most unprecedented storms and rainfall.

India's concerns arise from the fact that it has a long, densely populated coastline of more than 7,500 kilometres, which is exposed to the vagaries of climate change. These changes will have the severe implications on the livelihoods security of hundreds of thousands of people living in India's coastal areas. In the past, coastal zone management hardly mentioned climate change. But the recent devastations in various parts of the country due to rising sea levels, storms and cyclones (which are predicted to increase in frequency and intensity) have brought back the focus on Integrated Coastal Zone Management and Marine Protected Areas which are the two current answers to that huge challenge.

Integrated Coastal Zone Management provides for adaptation through balancing environmental, economic, and social objectives. Adaptation mechanisms include afforestation of mangroves, and involving local population in the management of protected areas, be it coral reefs, sea grass meadows or fish spawning grounds. Such measures must be combined with policy adjustments and incentive structures to encourage the protection and sustainable management of valuable coastal ecosystems.

Impact of Climate Change on Coastal Zones

Coastal zones are among the most densely populated regions with 50% of world's population living in coasts and this is expected to increase to 75% by the year 2020 (BMVBS 2009). Increasing human

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settlements, economic and development activities along the coasts is already putting enormous pressure on their ecological resources. Climate change impacts are already impacting the nature of coastal and ocean ecosystems, threatening the livelihoods of millions of people living in coastal areas. The mean rise in water surface temperatures is leading to coral bleaching and death of coral reefs. Salt- water intrusion is resulting in the spread of brackish estuarine systems, with implications for agriculture and aquaculture. Coastal erosion is increasing due to the gradual disappearance of mangrove shelterbelts and sea grass beds. The decline of coral reefs and mangroves affects marine biodiversity and fisheries production:

Mangroves: Mangroves help sequester large amounts of carbon - approximately 25.5 million tons every year. Mangroves also provide more than 10 % of the essential dissolved organic carbon that is supplied to the global oceans from land. Their role as a carbon sink is a service of particular global importance - mangroves and their soils are the second largest repository of terrestrial sequestered carbon after tropical forests. Mangroves affect sediment carbon storage both by direct inputs as a result of production and by increasing sedimentation rates. Conversely, clearing mangroves can rapidly decrease this storage capacity.

Sea Grasses: Although standing biomass of sea grasses is relatively low, the absolute rate of net production and therefore carbon uptake is comparatively high. Sea grass leaves degrade slowly and through their root and rhizome system, sea grasses deposit large amounts of underground, partly mineralized carbon. Thus, they constitute an important carbon dioxide sink, responsible for about 15 % of the total carbon storage in the ocean.

Coral Reefs: Coral reefs do not sequester carbon. Unmanaged reef metabolism is a net carbon-di- oxide source, because of side-effects from calcium carbonate precipitation. If calcification declines due to climate change (e.g. because of warmer waters or ocean acidification), this could in theory reduce carbon-di-oxide emissions from corals, because dead corals do not emit carbondi-oxide. But the huge ecological side effects from these losses would more than cancel out any advantages. The role of coral reefs is more one of reefs being likely beneficiaries of carbon-dioxide management. They also protect coastal communities and terrestrial ecosystems from incursions from the sea (Source: adapted from Dudley et al. 2010 and Ong 1993).

Coastal zones are complex ecosystems. Climate change impacts such as warming temperatures, sea-level rise, and changing precipitation patterns will severely affect them(Murray 2005). It is predicted that climate change will increasingly „endanger the food security, water security, health, and livelihoods of coastal populations" (Michel 2010). The lives of over 40 million people living along the Indian coastline will be affected by the impacts of climate change. Not only do these people have their homes on the coast, many of them are also dependent on it to make a living, above all in climate-sensitive sectors like agriculture and fisheries (INCCA 2010).

Potential Impact of Climate Change on Coastal Zones

The following is an illustrative list of both general and specific impacts of climate change on coastal areas:

- Increase in air temperatures
- Heat waves
- Drought
- Wildfire
- Invasive species range expansion
- Rising sea levels(accelerated rise in sea level of up to 0.6 metres or more by 2100)
- Coastal inundation
- Erosion
- Storm surge flooding, increasing storm intensity/frequency
- Rising water tables
- Saltwater intrusion and salinity shifts
- Flooding
- High wind, high waves

- Increase in water temperatures (a further rise in sea surface temperatures by up to 3 ℃)
  - Coral bleaching
  - Pathogens and disease

- Harmful algal blooms
- Invasive species, shift in species range
- Ocean acidification
- Dissolution of calcium carbonate in shell-forming marine organisms

(Source: adapted from NOAA 2010).

Impact of Climate Change on Coastal Zones in India

Coastal zones in India have been subject to heavy pressures due to development and other human pressures. The poor ecological health of coastal areas can be judged from the points given below:

- All coastal states and territories in India are affected by coastal erosion.
- About 26 % of the mainland coastline is already seriously eroded and much of the coastline is actively retreating. In the state of Karnataka, for example, erosion has affected 249.6 kilometers of the state's total coastline of 280 kilometers.
- Rising sea levels and storms that are likely to increase in frequency and intensity will aggravate erosion - with serious consequences for the economy and the environment in the coastal states.
- By the middle of the century, the sea level in the Indian subcontinent will have risen 15-38 centimeters.
- A 1-metre rise in sea level would displace 7.1 million people in India as 5,764 square kilometers of land and 4,200 kilometers of roads would be lost. (Source: adapted from ADB 2010)

The Coastal Regulation Zone Notification 1991 of the Ministry of Environment, Forests and Climate Change is a programme for protecting and conserving India's coastal environment. It has been amended periodically which divides coastal areas into four coastal regulation zones (CRZs):

- Ecologically sensitive areas (CRZ-I);
- Built-up municipal areas (CRZ-II);
- Rural areas, whether developed or not developed (CRZ-III);
- Aquatic areas (CRZ-IV).

Each coastal state has a designated coastal zone management authority under the Coastal Regulation Zone Notification and is responsible for implementing the regulation and drawing up a coastal zone management plan. (Source: GIZ 2011). Interventions options for coastal zones can be divided into two categories:

- Structural interventions and
- Non-structural interventions.

Interventions like building walls, mangrove plantations, or beach restoration, would fall under the category of structural interventions. Examples of non-structural interventions are providing timely information, land use control programmes and risk insurance. The options can also be preventive or corrective. Actions taken before the impact are preventive actions. But once the impacts are felt, corrective measures need to be put in place swiftly.

In order to be able to adapt to climate change requires an assessment of how current and anticipated climate change is likely to affect societies and ecosystems. Based on this analysis, possible adaptation measures needs to be identified. The financial and economic costs of the measures need to be estimated to define priority measures. Aspects of governance must also be considered. Climate change response needs site specific approaches. Climate change is not only bringing new challenges, it is also exacerbating the human-induced pressures that already existed.

As compared to former coastal zone management approaches (that were often sector-based, short-term and geared towards small area management systems), the ICZM (Integrated Coastal Zone Management) addresses the broader issues of ecological sustainability and long-term community interest (Kenchington& Crawford 1993). It is based on cross-sector planning and pays greater attention to interactions among component parts of natural and human systems. It aims at a balance between economic development and protecting the environment and social values (ibid). It works on building cooperative partnerships so that individuals, nongovernmental organizations and different levels of governments are able to participate in decision-making and management (ibid).

The sheer unpredictability of changes in climate change components poses a challenge for coastal managers. Responsibility for policy development and global governance for adaptation to climate change rests with institutions like the Intergovernmental Panel on Climate Change (IPCC), the International Union for Conservation of Nature (IUCN) and the United Nations Framework Convention on Climate Change (UNFCCC). India has already developed its National Action Plan on Climate Change (NAPCC), which, among other things, sets up a programme for coastal zones with a focus on coastal protection and early warning systems. The NAPCC identifies several priority areas for India's coastal zones (GOI 2008):

- Developing an air-ocean circulation modeling system especially for the Bay of Bengal and the Arabian Sea, to simulate regional climate change and, in particular, monsoon behavior;
- Carrying out high-resolution ocean-atmosphere variability studies in tropical oceans, in particular the Indian Ocean;
- Engineering a high-resolution storm surge model for coastal regions;
- Developing salinity-tolerant crop cultivars;
- Raising community awareness on coastal disasters and necessary action;
- Establishing timely forecasting and cyclone and flood warning systems;
- Planting and regeneration of mangroves and coastal forests.

There are success stories in community involvement in mangrove restoration from different parts of India. One such initiative is from Tamil Nadu where extensive felling of mangroves for generating revenue resulted in increased salinity, loss of biodiversity and completes degradation of the Pichavaram wetland. Pichavaram mangrove wetland is located at the northernmost end of the Cauvery delta in Tamil Nadu. It covers a total area of about 1,470 hectares, consisting of about 50 small, yet inhabited islands. The M.S. Swaminathan Research Foundation (MSSRF), with the support of the State Forest Department (Government of Tamil Nadu) and the participation of local mangrove user communities started a programme of mangrove restoration on a small area of 10 hectares. Artificial canal systems were built, enabling tidal water to flow freely to and from the degraded areas, increasing the soil moisture and decreasing soil and groundwater salinity. This made the area suitable for mangroves to be planted with good chances of survival.

Coastal ecosystems like mangroves, sea grass beds, and coral reefs are able to protect coastlines and mitigate climate change impacts. Physical infrastructure can be enhanced through appropriate dyke design, use of barriers to break waves, limitation of erosion, increase of sedimentation, and rehabilitation of mangroves under relatively sheltered conditions behind the wave breaking barrier. Once areas at risk are identified, emergency preparedness and coastal zone response mechanisms need to be strengthened and optimized. Flexibility combined with know-how allows for the development of new strategies that can provide a buffer against the negative impacts of climate change by improving the chances of adapting more smoothly and painlessly. Then integrating programmes and plans for economic development, environmental quality management, and land use has to be done.

The task of integrating programmes is a major challenge in India. Sectors such as agriculture, forestry, energy, transport, water resources, waste disposal, and tourism have to be well coordinated right from the planning stage, to implementation, operation and maintenance, and monitoring and evaluation. Responsibilities for various management tasks need integration among different government levels from local, state, regional, national, and international level. Responsibilities have to be shared among different stakeholders from the public and private sectors and also among different disciplines like science and technology (ecology, geomorphology, and marine biology, engineering), economics, political science (institutions) and law. (Source: adapted from Shea & Dyoulgerov 1997 and Wong 2010).

Integrated Coastal Zone Management (ICZM) is an ideal strategy for climate change adaptation since it combines interventions in different sectors and eco-systems within coastal zones and provides for policy adjustments. ICZM encompasses:

- Protecting user rights for and access to marine resources for marginalized fisher folks and women;
- Managing conflicting interests between nature conservation, shipping, tourism and the fishing industry;
- Analyzing ecological, social and economic processes and perspectives in coastal regions;

- Developing sustainable land use systems for multiple use;
- Evaluation of coastal subsidence rates in sensitive coastal regions;
- Constructing coastal protection structures and raising the natural resilience and protective function of coastal ecosystems;
- Preventing habitat fragmentation and developing buffer zones and passage corridors for different species;
- Planning for human migration in response to sea level rise;
- Ensuring emergency preparedness for weather extremes;
- Developing financing systems for the protection and sustainable use of aquatic resources and coastal zones like eco-tourism.

Adaptation Strategies in Coastal Zones

In the nutshell, adaptation strategies in coastal zones can be the following:

- Creating income-generating measures for marginalized coastal populations;
- Designation and management of marine protected areas ;
- Reforestation and management of mangroves.

ICZM‟s adaptation strategy is holistic, which attempts to balance environmental, economic, and social objectives (Wong 2010). A wide variety of organizations are involved in ICZM, ranging from government ministries, to universities and non- governmental organizations. ICZM also has two sub-approaches, the community-based adaptation approach and the ecosystem-based adaptation approach. Community-Based Adaptation (CBA) is an approach enabling communities to enhance their own adaptive capacity and empowering them to increase their resilience to climate change impacts. This approach has shown success in many parts of India. This is a bottom-up approach where communities receive relevant information in order to help them in implementation.

Ecosystem-Based Adaptation (EBA) is used on the assumption that climate change will drastically transform coastal and marine ecosystems in ways that the present management will not be prepared to handle. EBA „takes a broader view of management decisions in order to understand the ecosystems themselves‟ (Wong 2010). The approach prepares „to take account of potential future changes that may be greater than those induced by present stresses, adopting a longer perspective that includes non-climate issues (ibid).

India's Coastal Zone Management Strategies

India has integrated adaptation to climate change into its coastal zone management plans. One example is the Integrated Coastal Zone Management Project to be coordinated by the Society of Integrated Coastal Management (SICOM), which was established by the Indian Government in September, 2010 (MoEF 2010). It has established a National Centre for Sustainable Coastal Management at Anna University, Chennai. The centre is working with the collaborating institutes in each of the coastal states and union territories.

Another programme in India is the Sustainable Coastal Protection and Management Investment Programme, which is being coordinated by the Ministry of Water Resources with financing from the Asian Development Bank (ADB 2010). The Asian Development Bank‟s environmental assessment report published in March 2010 promises:„ The approach to coastal protection and management will significantly change, in a well-planned and programmed transition from environmentally harmful protection (…) to environmentally appropriate and sustainable solutions‟ (ibid).

Marine protected areas (MPAs) have also been established in India to conserve marine environments. Some of the familiar MPAs in India include Marine National Park, Gulf of Kutch, Gulf of Mannar Marine National Park, and Mahatma Gandhi Marine National Park in the Andamans etc. They offer protection to mangroves, coral reefs and sea grass beds. MPAs protect marine and coastal ecosystems contributing to high biodiversity especially genetic diversity (GTZ 2002).Kelleher (1999) defines Marine Protected Areas as: „ (…) any areas of intertidal or sub tidal terrain, together with its overlying water and associated flora, fauna, historical and cultural features, which have been reserved by law or other effective means to protect part or all of the enclosed environment.‟

Conclusion

Coastal ecosystems, especially mangrove forests and coral reefs, act as buffers against extreme weather conditions and natural disasters, thereby reducing the vulnerability of coastal communities. They protect the shore line during storms and hurricanes. Mangroves are under severe threat from development and other local issues like being used as firewood. Integrating several ministries / departments at various levels, public-private partnerships, make the task of adapting to climate change a big challenge. By empowering communities to become resilient, implementation of policies would become much easier. The need is to declare more areas as MPAs. When it's a question of mitigation, the most important quality of MPAs is their ability to reduce CO2 emissions substantially? They help nature and society to mitigate climate change by sequestering and storing carbon in natural ecosystems. They are able to store huge amounts of carbon, particularly in coastal zones. Salt marshes, mangroves and sea grass beds have important potential to sequester carbon. But they are reeling under severe pressure and stresses. Without enough protection they can be sources of emissions rather than storehouses of carbon.

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