



SUSTAINABLE MANAGEMENT OF COASTAL ECOSYSTEM

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Integrating Sustainable Coastal Development Initiatives along Maharashtra Coast, using ICM Guidelines

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Abstract— Around 250 million of India's population reside within 50 km of the 7500 km coastline that is shared by 9 states and 2 union territories comprising 77 towns and cities including 3 megacities viz. Mumbai, Calcutta and Chennai. The coastline supports several economic activities that are vital for India's economy like oil & gas, ports & harbors, power plants, fishing, tourism and mining that keep affecting our coastal ecology and environment. Same time, it is important to note that Indian coastal stretches are well endowed with highly productive ecosystems that support coastal human population in numerous ways, ranging from alleviating their poverty by offering variety of coastal resources, to protecting them from natural and manmade hazards like erosion, cyclones, storm surges, tsunamis, pollution etc. Healthy coastal ecosystems are also considered as an effective and inexpensive defense against coastal hazards, besides being helpful in offering multiple options of livelihood for the coastal population. In the light of these facts, it is but natural to adopt an approach that balances between development and environmental wellbeing. But, of late, it is observed, that climatic change and anthropogenic stresses resulting from over-urbanization, ill-planned development, habitat fragmentation, overexploitation of resources, pollution from industry as well as anthropogenic sources are adversely affecting the ecological balance and the services being offered by the coastal ecosystems all along the Indian coast, thereby exacerbating vulnerability of the coastal population to various hazards. Hence, in order to improve the adaptive capacity of the coastal population, it is felt essential to restore the ecological balance by including ecological considerations into coastal planning and governance that can lead to enhancement of the resilience of the natural coastal ecosystem and thereby, increase the diversity of coastal livelihood. The best way to do this is by adopting the principles and practices of Integrated Coastal Management while aiming at sustainable development goals. This paper explains 2 major initiatives in this direction, one headed by the Maharashtra Maritime Board (MMB) viz. 'Sustainable Protection and Development of Coastal Maharashtra' and the other one, from Ministry of Environment and Forests (MoEF) viz. 'Enhancing Climate Resilience of India's Coastal Communities', that are aimed at restoring the coastal ecological balance through 2 separate eco-friendly interventions covering Maharashtra state. Further, the ways of harmonizing/integrating these activities with each other are also indicated in order to

achieve best results from all, in the context of the current coastal status and laws.

1. Introduction

India is exposed on all fronts to the impacts of climate change due to its unique geographical features like a long coastline of 7500kms (5,423 km in peninsular India and 2,094 km in the Andaman, Nicobar land Lakshadweep Islands), Himalayan mountain ranges and vast desert stretches. These impacts include melting glaciers, accelerated desertification, sea level rise and intense storm surges. According to the Inter-governmental panel on Climate Change (IPCC, 2013), by 2030s, temperatures are expected to increase in India by 1-4° c, with maximum increase in coastal regions. About 250 million people reside within 50 km of India's coast, which accounts for approx. 3.5 percent of the world's population. India's coastline covers nine states and two union territories with 77 towns and cities located along the coast, including megacities like Mumbai, Chennai and Kolkata, and 75 coastal districts. India's coastline supports a number of economically important infrastructure such as oil and gas, power plants, ports and harbors, aquaculture, agriculture, marine fishing, tourism, mining, reclamation, etc. Currently, there are 12 major ports and 187 minor ports, several industries including power plants and urban sprawl occupying 43 per cent of the coast. These activities contribute significantly to the country's economy, which accounts for one of the largest in the South Asian Region. The coast also harbors rich ecosystems with extensive mangroves, seaweed beds, salt marshes and coral reefs that provide ecosystem services and contribute significantly to poverty reduction. For example, the ecosystem services in Odisha coast contribute to approximately 60 per cent of the rural economy. Conservation and effective management of these ecosystems are also a part of important climate change mitigation strategies, as they contain rich carbon reservoirs. Degradation of coastal and



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marine ecosystems has a direct impact on the marginalized communities which are already vulnerable to climate change related impacts. The National Disaster Management Authority states that the Indian coastline is amongst the most affected regions in the world and exposed to almost 10 per cent of the world's tropical cyclones. It is estimated that the Bay of Bengal and the Arabian Sea are likely to experience strong climate vagaries over the coming years. India has already experienced many instances of extremes of temperature, rainfall and tropical cyclones in the period 2009-2016, resulting in enhanced exposure to multi-hazard vulnerability with adverse impact on natural resources, agriculture and related livelihoods. Climate change and human induced drivers of environmental degradation pose significant long term risks to the country's economic growth and could undermine India's efforts to achieve the Sustainable Development Goals. There is increasing evidence of coastal India being exposed to human-induced pressures from poorly planned developmental activities, land reclamation, habitat fragmentation, exploitation of resources, invasive alien species, pollution from urban and industrial effluents, and increased occurrence of Industrial disasters. These anthropogenic stresses further exacerbate the vulnerability of India's coastal areas to climate change impacts discussed above.

On the backdrop of the aforementioned facts, it is utmost essential to see that the ecofriendly initiatives in the region are well planned to support sustainable development, in order to strike a balance between our developmental needs and environmental aspirations. This paper discusses the methodology being adopted in 2 such initiatives along Maharashtra coast along with a comment on the possibilities how they can complement each other. The paper also provides results obtained from applying the proposed

methodology for Shoreline Management Plan to the available data from Mumbai coast.

2. Literature Review

Integrated Coastal Management is a continuous process of rational decision making with concern of conservation and sustainable use of coastal space and resources (Cicin-Sain and Knecht 1998). It requires the mediation of conflicts for allocation of resources with active involvement of interested stakeholders and public (GSAMP, 1996). ICM has distinct characteristics of balanced development, conservation, multisectoral planning with an added advantage of conflict mediation and participation. Fundamental purpose of ICM is to accomplish, “a sustained effort whose goal is to structure the allocation of coastal resources”, the rate in which coastal resources are used and “how conflicts among stakeholders are resolved” (Olsen et. al., 1998).

A comprehensive definition, provided by Knecht and Archer (1993) defines ICZM as:

“A dynamic and continuous process of administering the use, development and protection of the coastal zone and its resources towards common objectives of national and local authorities and the aspiration of different resource user groups”.

Sorenson (1993) gives a definition of ICZM as:

“Integrated management provides policy direction and a process for defining objectives and priorities and planning development beyond sectorial activities. It adopts a systems perspective and multi sectorial approach which takes into account all sectorial interests and stakeholder interests, and deals with economic and social issues as well as environmental and economic issues”.

Table 1 Existing research on specific mechanisms of ICZM and the corresponding emphasis. Indicated by an X in the appropriate column

Mechanisms	Source	Emphasis on	
		Institutional success	Sustainable management
Public participation	Anker et al. 2004	X	
Co-management task force	Crean 2000	X	
Consistency review	Portman 2007		X
Capacity building	Garriga and Losada 2010	X	X
Planning hierarchy	Allmendinger et al. 2002		X
Setback lines	Bernd-Cohen and Gordan 1999		X



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Environmental impact assessment	Budd 1999		X
Statutory management	Enemark 2005		X
Social impact assessment	Sievanen et al. 2005		X

3. Methodology

Coastal adaptation solutions include developing adaptive capacity of communities to diverse coastal livelihoods, enhancing the resilience of natural ecosystems, and including climate change considerations into coastal planning and governance. Barriers to addressing such adaptation solutions include poor inter-sectorial coordination and land use planning, promotion of unsustainable technologies, failure to integrate environmental and climate change concerns into development planning, poor enforcement, lack of alternative livelihood options, low adaptive capacity and poor preparedness. A necessary response to this challenge is to strengthen capacities of communities, local and state authorities and decision-makers to understand and harness the enormous value of ecosystems to local livelihoods and economy and in reducing climate change impacts through a well-planned growth.

The 2 major eco-friendly idea being attempted along Maharashtra coast, in line with the aforementioned goals are:

- i. 'The Shoreline Management Plan' by Maharashtra Maritime Board (MMB)
- ii. 'Enhancing Climate Resilience of India's Coastal Communities' by the MoEF through Maharashtra State Forest Department.

3.1. Shoreline Management Plan

The preparation of a Shoreline Management Plan (SMP) revolves around identifying land cover units that are vulnerable to shoreline erosion and deciding the future development plan based on the permissible land use under the law of the land, like CRZ Laws as well as the vulnerability status of the coastal land covers. The data requirements for this

exercise are: Topographic Maps, Satellite Data, Digital Elevation Models, Tidal Data, Bathymetry, Historical Hazard Data, Wave Run-Up Data, CRZ Maps, Population Growth Data.

Proposed methodology for Shoreline Development & Planning can be divided in 2 major parts such as Coastal Managing Unit & Coast Protective Measures. Coastal Managing Unit is combination of Coastal Landforms Units (CLU), Shoreline retreat, Coastal Processes Units (CPU) & Coastal rules & regulations. Whereas Coast Protective measure Unit is combination of Population growth rate & Risk associated with coastal processes. This methodology not only addresses Sustainable Development but also performs risk assessment of Coastal zone.

The Shoreline Management Plan (SMP) methodology for the Coastal City of Mumbai is provided in Fig 1. Output of CLU, CPU, Coastal Land use Characterization Units (CLUCU) in combination with each other forms Coastal Managing Unit. Coast protection Measures are suggested based on the analysis of Population Growth Rate & Coastal Process Unit. A Shoreline Management Plan decides Development & Non Development zone on the basis of CMU & Coast Protective Measures. This SMP not only preserves Ecological balance of Coastal zone but also addresses social & economic balance of the region.

The SMP is best executed with the help of GIS where various layers of information can be effectively stored, co-registered, scientifically manipulated and retrieved as per the needs of planners and decision makers.



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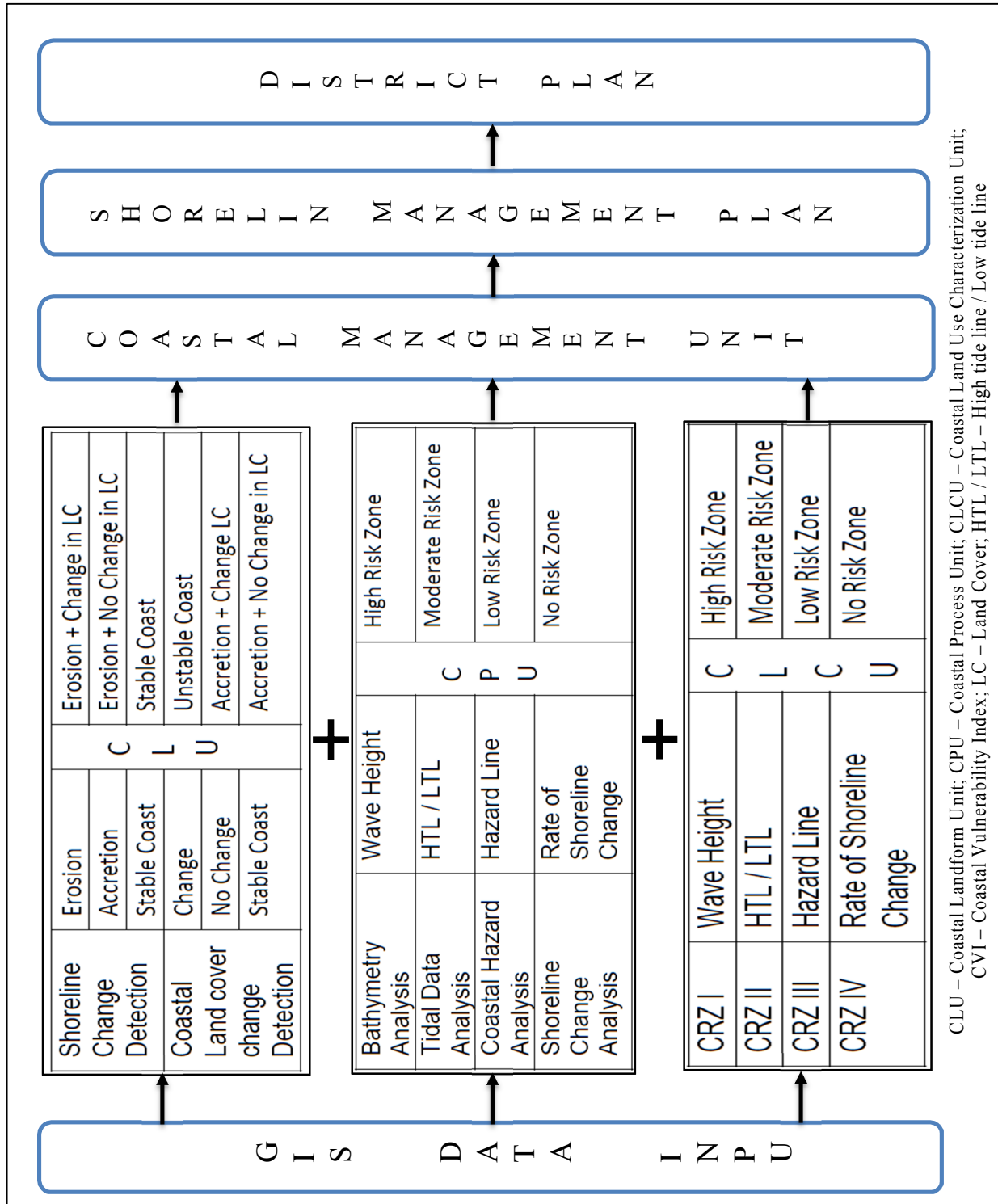


Fig 1 System architecture of shoreline management plan



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3.2. 'Enhancing Climate Resilience of India's Coastal Communities'- Ecosystem based adaptation in coastal India:

Coastal ecosystems have proven to be effective buffers and a good first line of defence against the impacts of extreme weather events and disasters like providing essential goods and services to local people. Consequently, the sustainable management and maintenance of coastal ecosystems is considered to be a cost effective and essential strategy in support of climate change adaptation. The UNFCCC recognizes that ecosystems play a crucial role in adapting to climate change at all levels. In effect, ecosystem based approaches address both climate change mitigation and adaptation efforts and provide multiple benefits. Though in India, the conservation of coastal habitats has been accorded high priority, its potential in supporting communities in adapting to climate change impacts is yet to be assessed comprehensively. Studies have shown that mangroves can reduce the impacts of cyclones and tsunami while also providing essential goods and services for coastal communities. This initiative will adopt an ecosystems based adaptation approach including the conservation, restoration

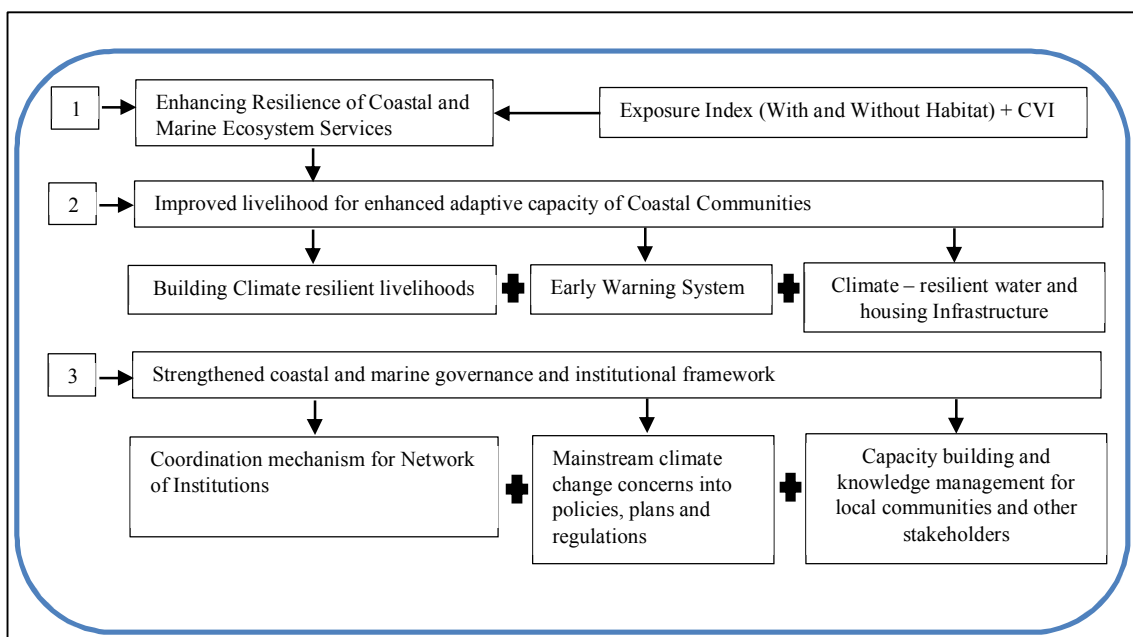
or introduction of vegetated coastal ecosystems as a cost-effective option for addressing the increased risk from flooding and erosion caused by climate change in vulnerable areas.

3.2.1. Proposed Objectives

The objective of this project is to enhance the resilience of the lives and livelihoods of the most vulnerable populations, particularly women, in the coastal areas of India to climate change and extreme events. The expected key Fund level impacts are increased resilience and enhanced livelihoods of the most vulnerable people, communities and regions as well as the ecosystems and ecosystem services. The key component of the project is enhancing climate resilience in the coastal areas of India through a landscape based ecosystem centric approach. The component comprises three inter-linked outputs-

- 1) Enhanced resilience of coastal and marine ecosystems and their services.
- 2) Improved livelihoods for enhanced adaptive capacities of coastal communities;
- 3) Strengthened coastal and marine governance and institutional framework.

Fig 2 Proposed methodology for enhancing climate resilient of coastal and marine ecosystem services (MoEFCC)



- Integration of SMP and proposed methods of enhancing climate resilience

Inputs from detailed shoreline management plan can be an input for coastal vulnerability index which can serve as an indicator to identify and prioritize the regional locations for implementation of climate resilience actions. Multiple scenarios with habitat and without habitat can give an estimation of the extent under stress for decision making. Exposure index is directly dependent on coastal vulnerability which can be estimated using GIS data coupled with shoreline management plan. Furthermore, SMP driven hotspots will act as an identifier for implementation of

climate resilient plan at various stages as mentioned in the proposed methodology for improvement of livelihood of coastal communities and strengthening of institutional framework.

4. Results for Shoreline Management Plan

4.1. CLU for Mumbai Coast

Mumbai Coast Topographic map of Year 1955 & remotely sensed satellite images of year 1999 & 2012 were used for this purpose. Landsat 5,4 and 3 band image combinations are considered. By visual interpretation, shoreline has been mapped for years 1999 & 2012.

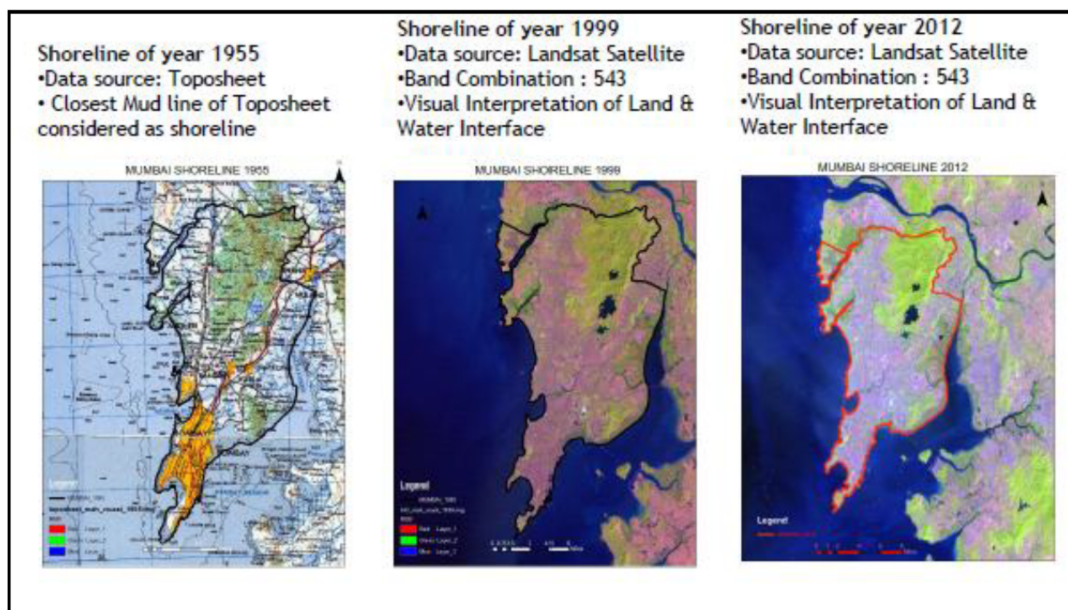


Fig 3 Shoreline Maps of Mumbai Coast for year 1955, 1999, and 2012

4.2. Shoreline Management Plan for Mumbai Coast

Shoreline Management Plan comprising CPM & CMU, formulated with help of Remote

Sensing & GIS divides whole coastal zone in development zone & Non development zone along with suggestion of construction of coastal protective measures.

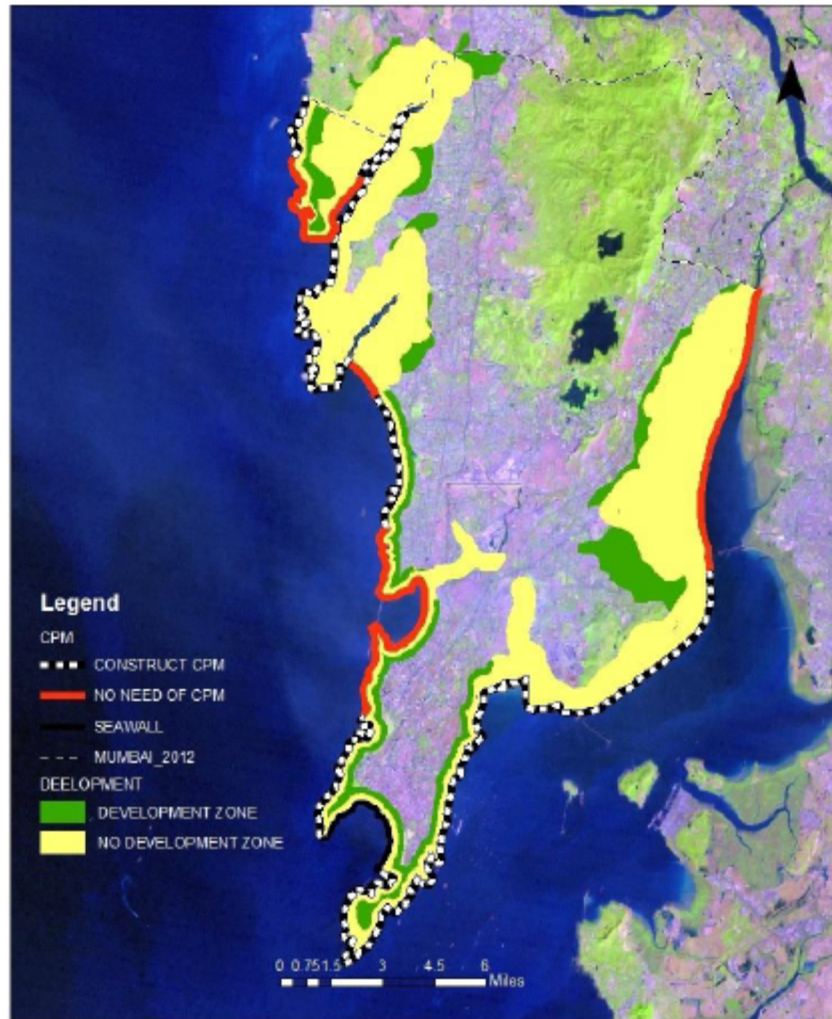


Fig 3 Shoreline Maps of Mumbai Coast for year 1955, 1999, and 2012

5. Results for ICM Initiatives

5.1. Enhanced Resilience of Coastal and Marine Ecosystems and their Services:

- Comprehensive climate vulnerability assessment to prioritize vulnerable stretches for ecosystems based interventions

An initial vulnerability assessment of coastal communities, towns and ecosystems will be undertaken as part of the feasibility study during proposal development, in order to ensure a solid evidence base for the activities and scope of the full

project proposal. In the project itself, a comprehensive coastal climate vulnerability map of the whole of India will be prepared, and highly vulnerable coastal stretches will be identified. A detailed methodology based on the existing IPCC method will be developed for Indian conditions. This addresses the barrier posed by the incomplete state of information on vulnerability to climate change impacts along the whole of India's coastline, and information on specific local scale potential for ecosystem-based adaptation interventions.



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- Conservation and restoration of coastal ecosystems for increasing ecosystem resilience.

Ecosystems based interventions will be conducted in the form of conservation and restoration of ecosystems (mangroves, corals, marshes, sea grass, etc.) in identified coastal stretches. Vegetated coastal ecosystems are important in protecting the coast against flooding and erosion due to waves and storm surges under mean and extreme conditions, including hurricanes whose intensity is predicted to increase with climate change. Recent findings on the remarkable capacity of vegetated coastal ecosystems for CO₂ sequestration and storage, and their capacity for sediment accretion and coastal protection, have converged to identify these habitats as essential elements of a strategy that combines both climate change adaptation and mitigation. The eco-engineering approach could become socially and economically efficient and may offer greater opportunities for countries-especially developing ones-to achieve sustainable targets even under limited financial resources and capacity.

- Monitoring blue carbon storage and sequestration to mitigate climate change

The use of vegetated coastal ecosystems to protect and restore lost CO₂ sink capacity and prevent the loss of deposits to mitigate climate change is not widely understood amongst decision-makers in India, posing a barrier to maximizing the use of natural ecosystems as part of managing multiple climate risks. "Blue Carbon" initiatives to maximize and monitor the contribution of coastal and marine ecosystems to avoided emissions of GHGs were first discussed in India in 2009. The project will assess the potential of blue carbon sequestration for coastal areas of India and monitor and report on quantities carbon sequestered through specific interventions in three target states, using standardized global methods.

5.2. Improved livelihoods for enhanced adaptive capacities of coastal communities

- Building climate resilient livelihoods

The project will combine government co-financing for livelihood support with GCF resources to address the incremental costs of incorporating climate change adaptation concerns. The lack of technical capacity will be addressed by undertaking extension and technical support, focusing on a) livelihoods that are linked to ecosystems and the services provided by them, such as fishing, aquaculture, mariculture, apiculture, pisciculture, eco-tourism, coastal agriculture etc., b) alternative livelihood opportunities through skill development to reduce dependence on ecosystems, and c) developing work opportunities for coastal ecosystem based activities like mangrove protection and restoration, coral reef enhancement, reducing erosion in estuary mouths, etc. Local communities and CBOs will be involved in the planning and implementation phase of the ecosystem enhancement. The feasibility study will explore opportunities along the coasts of the three target states, including potential for new market linkages and value chain development.

- Improving capacities of local communities on climate resilient planning and early warning systems

Through trained community members, climate change messages will be communicated to coastal communities and stakeholders of the coastal areas for efficient adaptation and mitigation. These trained community members will also share the message of successful livelihood related interventions to other villages. This has been found to be effective in Wadatar village in Sindhudurg, Maharashtra, where the local women were trained in mussel and oyster culture, an important livelihood activity which has now spread to other villages.

- Climate-resilient water and housing infrastructure for coastal villages and towns

When considering climate related risks, it is essential to ensure provision of basic development needs such as housing and water supply, while ensuring integrated approaches by all sectors. The project will support the existing government schemes



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and program to integrate climate change adaptation into processes to create new and/or strengthen existing amenities related to essential needs of communities, with special reference to water infrastructure and human settlements.

5.3. Strengthened coastal and marine governance and institutional framework:

- Network of institutions for enhanced climate resilience and integrated planning in coastal states

Partnership and cooperation amongst the institutions would be established by mainstreaming climate under the UNDP Government of India Coastal and Marine Programme-Mangrove and Marine Biodiversity Conservation Foundation, in Maharashtra and the East Godavari River Estuarine Ecosystem Foundation in Andhra Pradesh. Similarly, the Gulf of Mannar Biosphere Reserve Trust was established as a coordination body under a UNDP supported project. Climate resilience will further be incorporated into the mandate of these existing institutions.

- Mainstream climate change concerns into policies, plans and regulations related to coastal governance and strengthen their enforcement across sectors.
- Capacity building and knowledge management for reduced vulnerability.

6. Conclusion

Multiple initiatives highlighting the need for adherence to ICM principles and practices in developmental activities is the need of the hour and is being reflected in the recently proposed endeavors. It is however essential to see that such activities complement each other in order to draw maximum benefits out of them in terms of economic as well as ecological needs of the region.

Many risk assessment methodologies, rules and regulations are in use in India to prevent loss of life in coastal region. Most of the methodologies have attached more importance to economy of the region. However, natural hazard events occur due to

disturbance in ecological balance & uncontrolled land reclamation in coastal zone. Exploitation of natural coastal resources beyond the optimum limit is expected to lead to scarcity in future. For developing country like India, it is equally important to fulfil needs of population & maintain social as well as economic balance during development phase. Adoption of Sustainable Development practices is hence the only solution that can strike a balance between ecology, economy and social aspects. Shoreline Management and Planning is one of the major parts of Sustainable Development. Along with SMP, we need to train population residing in coastal zone for social awareness during hazardous event.

In order to achieve resilience, effective multi stakeholder governance of India's coast for adaptation to climate change needs to be combined with well managed coastal ecosystems maximizing the delivery of ecosystem goods (such as harvested products), and services (such as buffering extreme events). A number of barriers to achieving these outcomes are currently in place. There is currently a lack of understanding of the effectiveness of coastal ecosystems as natural buffers during extreme events. Limited evidence is available on the importance of coastal ecosystems as carbon sinks for India. Technical capacity of coastal communities and governance institutions is also currently limited, both for effective co-management to maximize ecosystem-based livelihoods and for making coastal infrastructure, such as housing and water services, resilient to climate change impacts. There is a need for detailed information on vulnerability to these impacts along the whole of India's coastline, including analysis of socio-ecological sensitivity and adaptive capacity, as well as detailed information on potential for ecosystem-based adaptation investments and comprehensive systems for making early warning information accessible to all.

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