Coastal Issues and Concerns: Challenges for the Research Community

Prepared by
Consortium of Coastal Academic Institutions
for the
National Centre for Sustainable Coastal Management (NCSCM)



Ministry of Environment and Forests
Government of India, New Delhi

Anna University Chennai
Chennai

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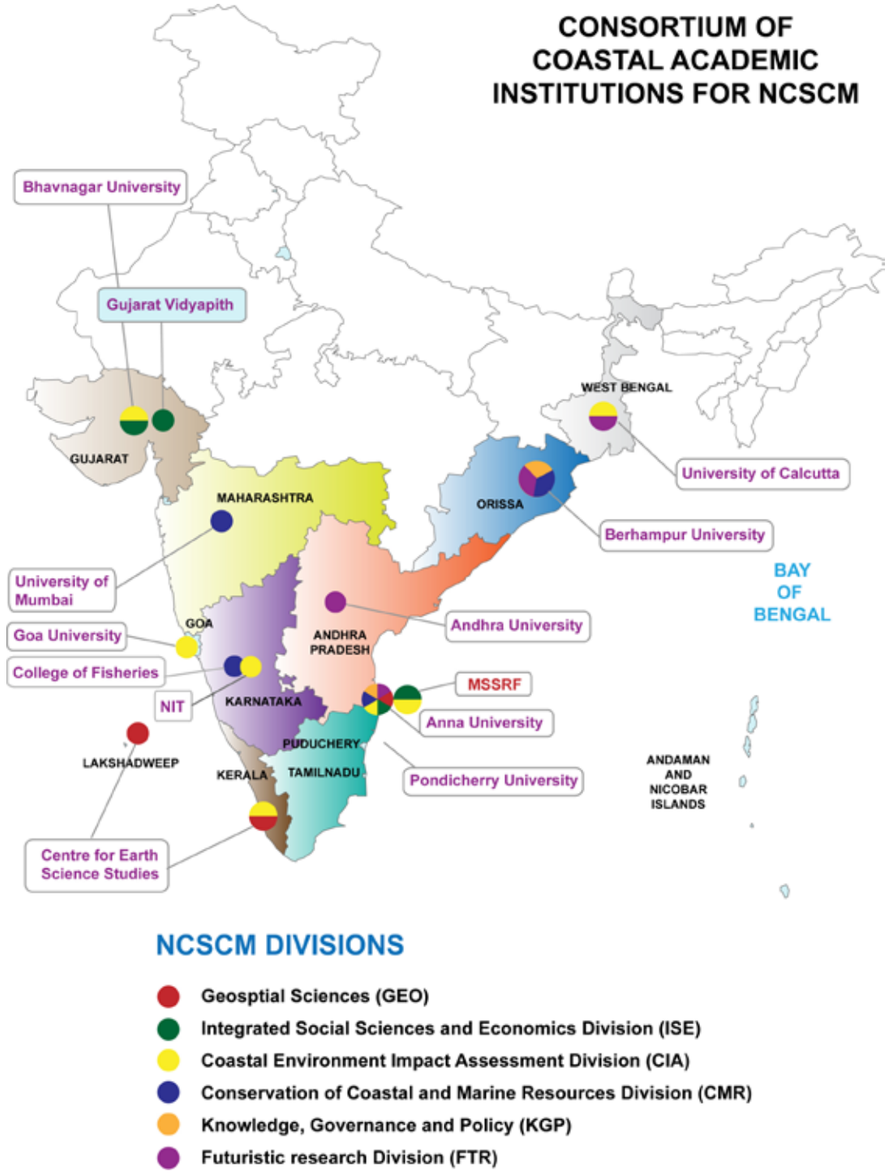

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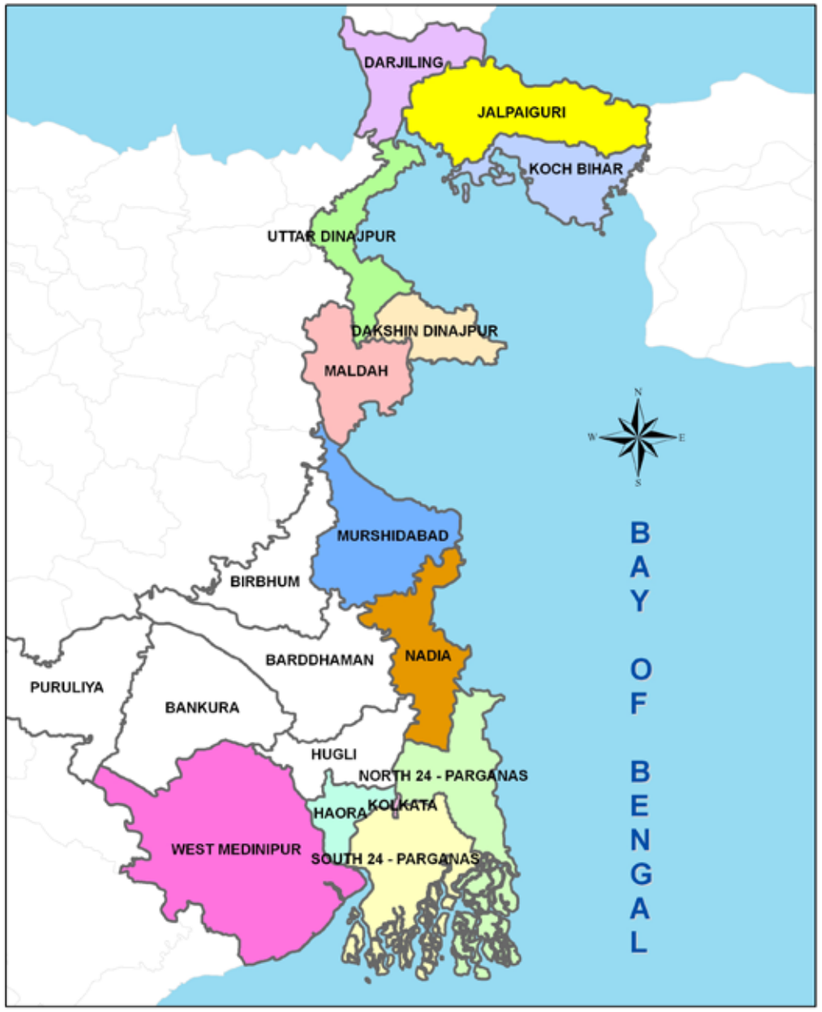
COASTAL DISTRICTS OF WEST BENGAL



Mangroves cover about 22 million ha globally, but their area has been decreased by human activity to 15 million ha in the last several decades. Sundarban mangrove, the largest mangrove wetland in the world and located between latitude 21°31′00′′ N and 22° 30′ 00′′ N and longitude 8°10′00′′ E and 89° 51′00′′ E out of which 4264 km2 of intertidal area, covered with thick natural mangrove forest, is subdivided as forest sub ecosystem and 1781 km2 of water area is aquatic sub-ecosystem. India's mangrove forests are estimated to cover about 356,000 ha with 58 different species. They are distributed along the eastern coast (80%) to the western coast (20%) and are concentrated in the Andaman and Nicobar Islands (Bay of Bengal) (Kathiresan and Rajendran, 2005).

Salient features of Sundarban

1. The mean elevation of Indian Sundarbans above sea level is about 3.30 m and the mean highest high water level (MHHW) and mean lowest high water level (MLHW) are 5.94 and 0.94 m, respectively (Untawale, 1986).
2. The forest floor is 0.91m to 2.11 m above mean sea level.
3. Approximately 2069 sq km of the area is occupied by the tidal river system or estuaries, which finally end up in the Bay of Bengal. Presently, the rivers in the western part of the forest (Hooghly and Muriganga) are connected to the Himalayan glaciers through the Ganges whereas the five eastern sector rivers, eg. Saptamukhi, Thakuran, Matla, Gosaba and Harinbhanga, are all tidally fed.
4. It is the last frontier of Bengal flood plains, a sprawling archipelago of 102 islands, out of which 54 are impacted.
5. The land–ocean boundary of the Sundarban mangrove forest, north-east (NE) coast of Bay of Bengal is highly irregular and criss-crossed by several rivers and waterways. East to west this area is about 140 km from the east boundary to the west boundary and 50–70 km from the shoreline to the north boundary. Several discrete islands and low lying intertidal zones are covered with thick mangrove forest. Height of natural mangrove plants genera such as Avicennia, Acanthus, Aegiceras, Bruguiera, Ceriops, etc. >10m is rare.
6. The climate of the area is dominated by south-west (SW) monsoon (June–September), NE monsoon or postmonsoon (October – January) and premonsoon (February–May). The seasonal maximum and minimum temperatures of the atmosphere were 30.771.5 and 21.574.6 1C in June and December, respectively. Salinity of the tidal water varied between 19.79% and 26.56%.
7. The Ganges drains much of the southern slopes of Himalaya and delivers an enormous amount of sediment to the Bengal fan. Sundarbans soil is in general medium textured, sandy loam, silt loam or clay loam, the grain size distribution is highly variable. Silt loam is dominant textural class.

1. Primary issues of West Bengal coast:

a. Erosion
The coastline of West Bengal along the Bay of Bengal is about 350 km long and is dominated by the Ganga delta, which covers around 60 % of this coastline. This is being attacked by sea waves and destructive tidal currents, which have produced erosive transgression over the sub-aerial part of the sub-delta. Frequent embankment failures, submergence and flooding, beach erosion and siltation at jetties and navigational channels, cyclones and storm surges are all making this area increasingly vulnerable.

b. Anthropogenic pressure
The natural ecosystem of the Sundarbans mangrove wetlands is under threat due to anthropogenic activities. Around 680 million tons of untreated sewage goes into the sea including hazardous industrial waste and fertilizers.

c. Diffused CRZ line due to continuous erosion/accretion phenomenon
The width of the beach varies from 104 m in the eastern part to a maximum of 320 m in the western part of Sundarban. There is about 20 m landward transgression of the shoreline in the eastern part since 1985 to 2004 causing extensive beach erosion in this part of the beach, whereas in the western part it is almost stable; rather, a deposition of sediments took place (Purkait, 2009).

d. Sea level oscillation due to climatic, geological/ physical factors
Loucks et al. (2010) estimated sea level rise of 28 cm in the next 50–90 years. If actions to both limit green house gas emissions and increase resilience of the Sundarbans are not initiated soon, the habitat tigers of the Sundarbans may join the Arctic's polar bears (Ursus maritimus) as early victims of climate change-induced habitat loss.

e. Global warming and biosphere –atmosphere exchange of trace gases
The partitioning of the incoming solar radiation in the Earth's atmosphere depends on the mixing ratios of different green house gases in the atmosphere and their resultant concentration after their exchange from the atmosphere by the biosphere. The history of climate and atmospheric composition reveals a tight coupling between biogenic trace gases in the atmosphere and the global climate (Petit et al., 1999).

2. Possible areas of research

A. Carbon storage: Potentiality of Sundarbans mangrove ecosystem for carbon storage and steps to be undertaken for its improvement

B. Time series analysis of biosphere-atmosphere interactions of methane (CH4)
Exchange of CO2 and CH4 between the Sundarban mangrove ecosystem and the atmosphere was studied earlier by Mukhopadhyay et al. (2001) continued by Ganguly et al (2008). For better understanding of the biosphere-atmosphere interaction at the land - ocean boundary condition of Sundarbans, NE coast of Bay of Bengal future study need to be carried out with special emphasis on time series modeling of green house gases such as CO2, CH4 and N2O. Ganguly et al. (2008) reported 10 %increase in methane emission in the Sundarban mangrove swamp during the interval between 2000 and 2008. The rate was found to be of 1.61 ± 1.2, 1.20 ± 1.61 and 1.72 ± 0.86 µg m-2 s-1 during pre-monsoon, monsoon and post-monsoon seasons, respectively in 2008. Lower values of CH4 mixing ratio and emission flux were obtained during monsoon period when the rainfall was the maximum and highest during postmonsoon due to low photochemical oxidation of methane by UV radiation during winter solstice when the net incoming solar radiation is least. CH4 mixing ratio over Sundarban biosphere exhibited an annual increase of 3.6 ppb during the period between 2000 and 2008 (Mukhopadhyay et al. 2002; Ganguly et al., 2008), being higher than the global rate 1.887 ppb yr-1 (Dlugokencky et al. 2009).

C. Sulfur biogeochemistry and aerosol formation
Interest and research in volatile sulfur compounds have developed rapidly because of their reported contribution to air pollution, climatic effects and precipitation chemistry. In the Sundarban Mangrove ecosystem, NE coast of Bay of Bengal, India one of the productive estuarine regions of Indian Coast, biogeochemistry of sulfur is of interest to study (Canfield et al., 1993). Biogenic sulfur gases emission from the natural sources are reported to be equivalent to anthropogenic emissions (Andreae and Jaeschke, 1992; Bates et al., 1992), this natural sources have a substantial impact on the global sulfur cycle (Istvan and Delaune, 1995). Dimethyl sulphide, Hydrogen sulphide and carbonyl sulphide are the precursor for non-sea salt sulphate formation in aerosol, which has negative feed back to warming of regional climate.
D. Nitrogen biogeochemistry: Study of nitrogen biogeochemistry in this unique land-ocean boundary condition could be a very important subject to deal with. Nitrification and denitrification rates in both the mangrove waters and sediment and subsequent N2O emission to the atmosphere are yet to be studied along the West Bengal Coast.

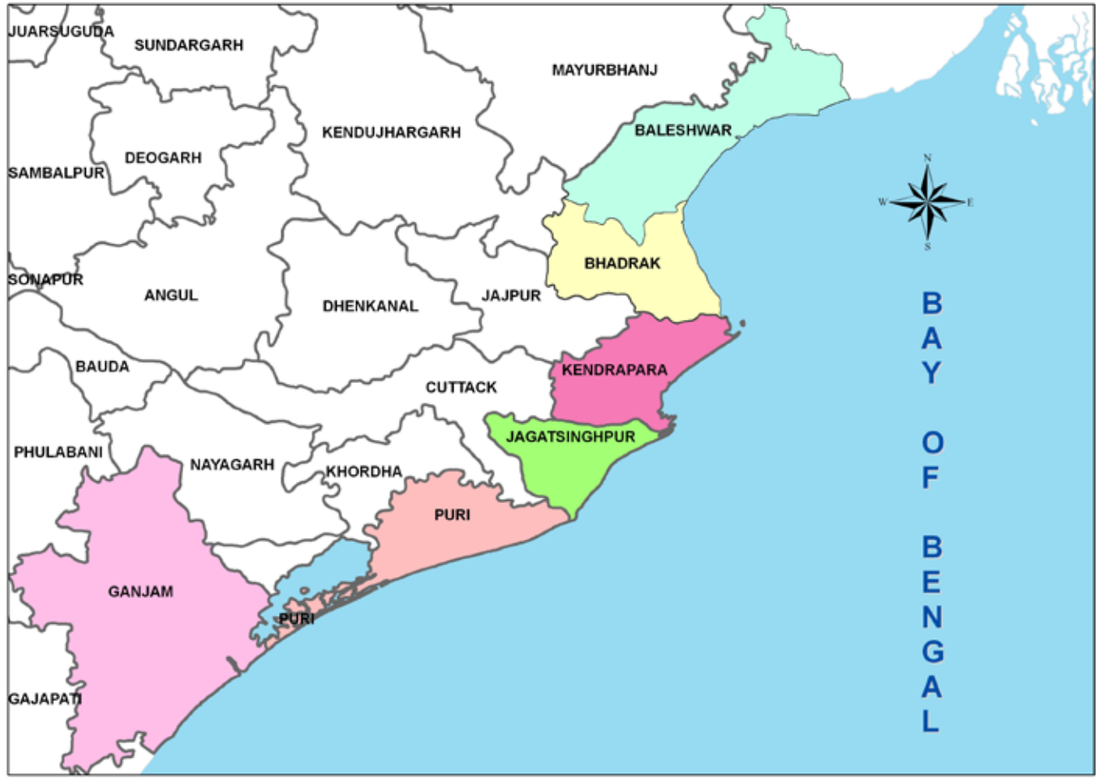
E. Plankton Ecology:
Study of primary and secondary productivity as well as the whole phytoplankton and zooplankton ecology is important to understand the role of food web for carbon sequestration and their sensitivity to climate change.

F. Biological control of Arsenic pollution: Occurrence of Arsenic in the surface and ground water is a burning issue to mitigate in the West Bengal coastal area . Preliminary study showed that biological control of arsenic is a promising aspect to explore (Mandal et al. 2009).

G. Climate change and foraminiferal response – Biostratigraphic markers
Foraminifera could provide information on physical, chemical and biological condition of an ecosystem and therefore, has emerged as a potential tool for assessing any climatic/environmental changes. The study of temporal and spatial distribution of living and dead assemblage of benthic foraminifera could provide information regarding the impact of climate change in this region.

H. DNA damage : Environmental stress due to continuous exposure of organisms to chemical mutagens like Ni, Cr, Hg, PAH etc. and nitrogen limitation to change the DNA base composition are of interest to study

COASTAL DISTRICTS OF ORISSA



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1. General Information on - Orissa Coast

- 480 Km Coastline.
- Six major estuaries.
- India's second largest mangrove forest (Bhitarkanika Sanctuary).
- Asia's largest brackish water coastal lagoon (Chilika),
- Extensive sandy beaches rich in heavy minerals (Indian Rare Earths Ltd.).
- World's largest rookery for the Olive Ridley sea turtle around Gahirmatha and two species of horse-shoe crabs.
- Southern part of the coast has a narrow shelf whereas the north Orissa coast has an extended continental shelf. Continental Shelf : 24000 Km2
- Coastal Districts : Six
- Coastal Population : 36% of Total Population and 43% of Urban Population
  Fisherman Population (coastal) : 1,73,197
- Fishing Potential : 2, 08, 000 Tonnes
- Climate : Moist sub humid or Dry subhumid type and Megather mal
- Rainfall : 1100 to 1500 mm
- Port : Major (1), Minor (1)
- Fishing Harbour : Major (1), Minor (3)
- Tidal Regime : Micro-meso Tidal
- Wave Characteristics : Wave Height (1.0-2.6 m),
  : Wave Period (5-14 Seconds)
- Currents : NW (Jan-Jul), SW (Aug-Dec)
- Gross Littoral Drift : 1.5-2.0 million m3 /year
- Landuse Pattern : Rice Fields, cultivated crop lands, irrigation canals, salt pans, aquaculture ponds, settlements,ports, 3 industries and recreation.

2. Important Coastal Marine Resources of Orissa

FISHERY RESOURCES

Capture from sea	:	1,56,081 ton
Capture from brackish water	:	16,782 ton
Coastal aquaculture	:	3,081 ton

MANGROVES

- Mangroves are confined to Kendrapada, Jagatsinghpur, Bhadrak and Balasore coast.
- Mangrove vegetation in Orissa is under going changes mostly due to cyclonic activities and change in the landuse/landcover pattern associated with population growth.

SEA WEED RESOURCES

An important agar-yielding algae, Gracillaria, present in Chilika lake.

OTHER BIOTIC RESOURCES

Horse shoe crabs, Sea turtles (Olive Ridley),Oysters,Dolphin, Crocodiles and Birds

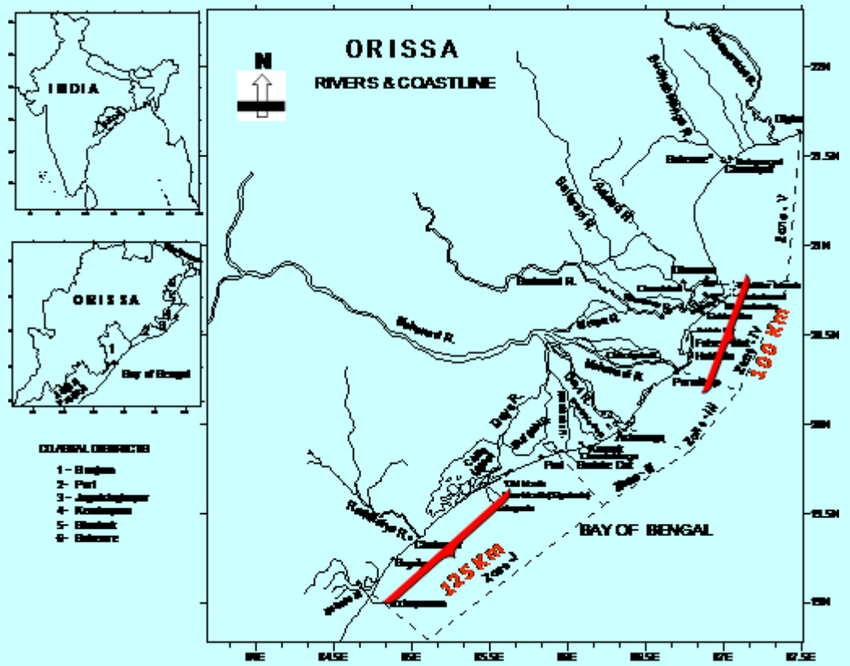
Orissa Coast showing locations of major towns and habitats

3. Major habitats along Orissa coast

Most of the coast is prestine with major ecosensitive habitats like Chilika, Bhitarkanika, Gahirmata, Devi, Rushikulya

4. Major activities along Orissa coast

- Coast least developed –Only one major port and 3-4 minor/fishing ports, 2 industries at Paradip and one at Ganjam
- Mining & tourism at Gopalpur – Tourism at Chilika, Puri, Konark
- Significant development proposed at Paradip and Dhamra.



- Two major ports at Gopalpur and Dhamra are coming up with private partnership. The government of Orissa has signed MoU for six ports, while it has proposal to construct 17 more ports.
- Orissa coast least studied in terms of coastal oceanography
- Tourism is an important sector and has immense potential for employment generation and to stimulate growth in the economy. Being a coastal state, it has beautiful beaches like Gopalpur, Puri, Konark, Chandipur etc. and other tourist spots such as Chilika lagoon, Bhitarkanika, Gahirmatha marine sanctuary which attract large number of tourists from India and abroad.
- ICZM programme launched for two sectors of the state, namely Gopalpur to Chilika and Paradeep to Dhamra, on a pilot basis with financial support from the World Bank

5. Major Issues along Orissa coast

- Orissa coast is frequently ravaged by cyclonic storms and associated flood causing colossal loss of life and property almost every year
- Significant beach erosion along Gopalpur, Konark, Puri, Paradeep, Pentha and Satbhaya- threat to life and livelihood of the coastal inhabitants
- Marginal decline in water quality at Ganjam, Puri and Paradip –coastal pollution
- Changing Chilika inlet dynamics – likely to affect lakes' ecology
- Changing shoreline causing shift in turtle nesting grounds (?)
- Impacts of Port structures and river discharges on coastal sediment circulation significant (?), likely to cause changes in bathymetry, beach profiles (?) – a vital factor for turtle habitats (?)
- River flooding and Flooding due to Storm Surges
- Coastal Landuse change and threat to the coastal bioresources
- Climate change and associated Sea Level Rise ??, Tsunami ??
- Biodiversity of coastal ecosystems such as Chilika Lagoon, Bhitarkanika etc.
- Livelihood of coastal population

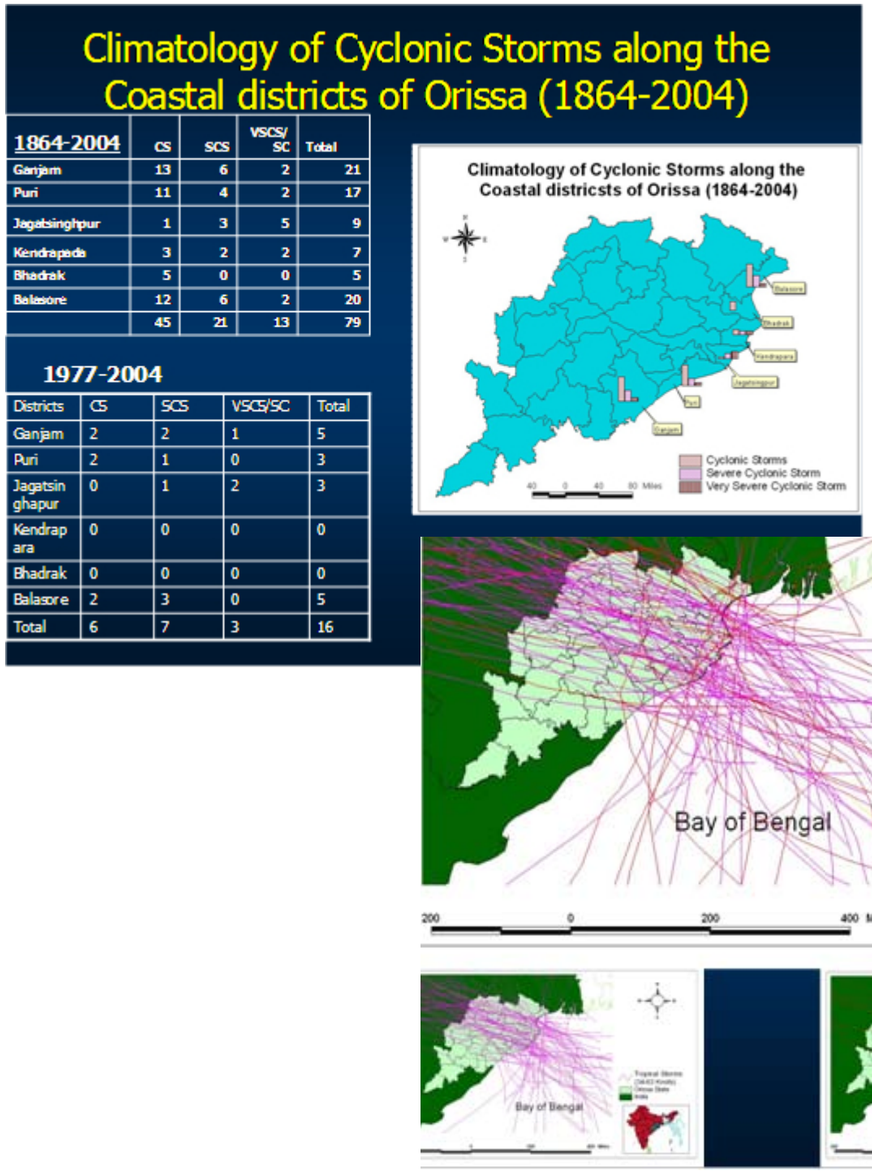
Possible areas of Research Collaboration between the Marine Sciences Department, Berhampur University and the NCSCM

Collaboration with NCSCM, a world class centre, would be of immense help in strengthening research and advisory support in the following areas:

- Climatology of natural hazards including cyclones, floods, tsunamis etc.

Storm surge modeling and coastal inundation mapping

- Vulnerability assessment/mapping due to cyclones, floods and sea level rise.
- Regional Coastal processes studies including estuaries and associated data.
- Impacts of ports and harbours on shoreline change, modeling shoreline changes and geomorphology along the coast,
- Oil spills monitoring and modelling etc.



- Resource management strategies with public participation
- Risk assessment studies
- Socio-economic analysis of impact of dev. activites & remedies like alternate source of livelihood opportunities
- Biodiversity conservation and management along with a database on all aspects of biodiversity esp endangered species
- Coastal pollution and water quality studies
- Landuse and land-cover study including Forest, mangrove covers
- Education and Public awareness programmes

Lessons from other coastal states like Andhra, Tamilnadu, Kerala, Karnataka, W.Bengal revealed that improper understanding of coastal oceanography led to several long-term damages like large scale beach erosion depriving living space for human, &loss of beach & other ecological habitats, pollution of near coast, siltation at river mouths etc. Orissa being least developed, problems are at initial stages and there is proposal for large scale development in future. Therefore, ICZM programme launched for the state for two sectors and the proposed collaboration of the Department of Marine Sciences, Berhampur University with NCSCM would minimise damages to coast and coastal habitats, ensure preservation of ecosensitive areas , provide appropriate management strategies to mitigate natural disasters like cyclones, floods and tsunamis and provide alternate livelihood options and thereby stimulate growth and economy of the state.

Present Research Activities at the Department:

1. Coastal processes studies along south Orissa coast: Waves, currents, tides were monitored in collaboration with ICMAM –PD continuously for one year. Besides, Several seasonal deployments were made. Beach profile, shoreline mapping, beach sediment and water quality characteristics over a stretch of 30 km along south Orissa coast are being monitored every month. The above data are being used in MIKE modeling system to develop a shoreline management plan for the south Orissa coast.
2. Tropical cyclone modeling and their risk assessment studies are being conducted. A long term cyclone climatology, coastal district wise, along with vulnerability zone mapping has been performed. A meso scale model (MM5) is being used to simulate cyclones.
3. Costal pollution and biodiversity studies at several specific points along the coast are made on a monthly basis.
4. Remote sensing data are being used to study the costal processes, productivity of the coastal ocean, landuse-land cover mapping and to detect shoreline change.

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Prelude

The Andhra University, having realized the importance of natural resources of the coastal, near and off shore environments, coastal processes, climatic conditions, marine food and agricultural products, aqua culture and placer deposits of the Bay of Bengal region, has established an advanced research center exclusively to study the Bay of Bengal and its environs in 2004.

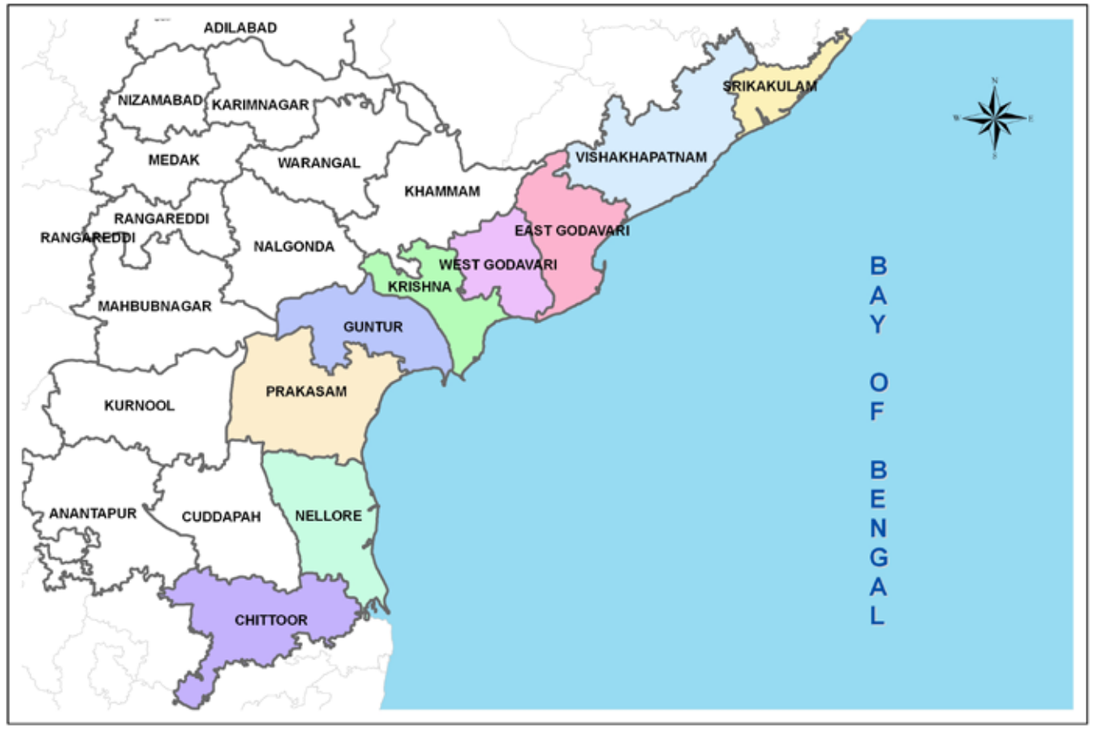
- The Center with a focus on a multi disciplinary approach defines its goals as follows.
- Evaluation of living and non-living natural resources of the coastal and near shore regions of Bay of Bengal and assess their sustainable levels.
- To understand the local and remote process- response characteristics of the coastal regions and oceans.
- To understand, characterize and predict the extreme events, like storm surges, tidal waves, cyclones, tsunamis etc.
- To utilize the scientific acknowledge for the socio-economic benefits of the coastal population and its development.
- To foster the concept of indigenous technology, in instrumentation, data collection, analysis and interpretation.
- To promote the popularization of science and its role in development and economy and awareness on mitigation and preparedness to handle the extreme events among the coastal population, public and government officials.

Present activities

Within the framework of these objectives, the Center has initiated a number research programmes sponsored by MoEs, INCOIS, DST etc., with a focuss on:

- Potential Fishing zones using the concepts of chlorophyll, sst, and wind patterns.
- Integrated Process response characteristics of coastal regions
- Ocean color retrieval from satellite data under SATCORE.
- Ecosystem modelling of Chilka Lake.
- Geospatial technologies in the restoration Kolleru wetland ecology.
- Mineral and chemical finger printing of beach placers
- Algal blooms of east coast of India

COASTAL DISTRICTS OF ANDHRA PRADESH



- Capacity building through training programmes catering to different target groups on topics of contemporary relevance.

Andhra Pradesh is endowed with a long coastline extending 974km starting from Nuralrevu village (near Ichapuram) abutting the Orissa State to Therunattam village abutting part of Pulicat Lake forms the southern tip of the coastal plain of Andhra . The coastline is densely populated with more than 30 million people living on the coast. The coastal population constitutes 40% of the total state population. These coastal populations

Coastal Andhra Pradesh (Source: Info Base Pvt. Ltd.)

mostly depend on the coastal and marine resources and partially on agriculture, aquaculture and industries located along the coastal zone. The coastal strip still enjoys rural atmosphere with fishing and agricultural as the main activity and sporadic presence of industrial establishments.

There are nine coastal districts in the state comprising of 508 fishing villages supported by an equal number of fish landing centers. The fishermen population is around 6.00 lakhs out of which almost 2.50 lakhs are full time fishermen. Presently there are five major harbours viz. Visakhapatnam, Kakinada, Nizampatnam, Machilipatnam and Krishnapatnam which actively support fishing and other port operations. More than 9000 mechanized boats and 50000 traditional crafts operated from the coastal districts of Andhra Pradesh.
The continental shelf area of Andhra Pradesh coast is spreads over an area of 33,277 sq.kms. The shelf region of Andhra Pradesh has promising hydrocarbon, carbonate, phosphate and placer mineral resources apart from

abundant living resources. Further the marine algae and many marine plants are recognized to prossess high medicinal value and various programmes to extract natural drugs from sea are under progress.

Andhra Pradesh occupies the 5th position among maritime states producing around 2.19 lakh tonnes of fish including shrimp in the marine sector. However it has a potential to produce 4.00 lakh tonnes.

On one hand the fishing and other activities along the Andhra Pradesh coast are quite intensive and have been highly productive both from food production and economy points of view while on the other the coast has been subjected to a number of natural hazards which are quite frequent, sudden and unwarranted. The summer monsoon depressions and severe storms cause extensive loss of life, apart from severe damage to property and crops across the Andhra coast. In addition to these unwarranted events, a regular and cyclic phenomena like erosion and deposition is prevalent in many parts of the A.P. coast. One of the striking examples is severe erosion that has been significantly damaging the Kakinada-Uppada coast. Interestingly the erosion and the associated accretion have been exhibiting a steady migration towards north. Such phenomena are the result of near shore bathymetry, current and wave pattern, salinity distribution and influence of fluvial activity contributed by estuaries and river systems entering the coastal waters along the coast.

Similar extreme events like, 2009 September floods, December 2004 Tsunami, Diviseema tidal wave of November 1977 which have engulfed the Andhra coast caused enormous damage to property and loss of life, not to talk about the the coastal structures and morphology. Many of the cyclones, depressions, and severe storms which are much more frequent have been causing comparable damage to the coast. Developmental activities like off shore jetties, small ports, the maintenance of entrance channels, offshore drilling activities for hydrocarbon resources have their own impact on the shallow bathymetry, coastal and near shore processes and living and non-living natural resources. All these factors control the coastal and near shore processes, resulting in unprecedented and unexpected dynamics in shoreline migration and coastal morphology. Pollution from industry and urban settlements has been largely responsible for the extinction of biodiversity including flora and fauna in the coastal and near shore waters. Mangroves cover has been reduced from 495km2 to 333km2 from the year 1987 to 2001. The rich mangrove population prevalent in Godavari deltaic environments has now become rare spices to find in that region either due to helpless livelihood practices of the local coastal population or the apathetic attitude of the government in protecting them. Fish population is reduced to one fourth due to environmental degradation caused by municipal waste disposal and industrial pollution. The coastal environments are often subjected to degradation at an alarming rate leaving a very gloomy future. The recent studies conducted by the NIO, RC, Visakhapatnam concluded that the impact of the anthropogenic inputs such as industrial effluents and domestic sewage has resulted in deterioration of water quality, causing mass mortality of fish due to asphyxiation.

Due to increasing coastal population and growth in mechanized boat operations all along the coastline, the socio-economic status of the fishermen community is now in a fragile state. It is time that a thorough understanding of the socio-economic status of the coastal population, their limitations to compete with affluent business partners should form the basis to evolve a scientific strategy or model that can provide a balanced approach for a sustainable economy and professional growth of the coastal population and yet leave a clean coastal environment for the posterity.

Though a number of programmes were initiated by the Government to continuously monitor the changes in shoreline geometry and the coastal resources, unfortunately no record is available, leading to duplication of work by multiple agencies and individuals quite frequently.

Thus it can be conclusively recorded that the coastal regions of Andhra Pradesh are under severe stress influenced by different natural and anthropogenic activities in addition to natural hazards. As such some of the pertinent issues which deserve immediate attention are:

1. Coastal erosion
2. Indiscriminate mining of placer sand deposits
3. Subsidence of coastal deltaic regions
4. Costal pollution
5. Influence of rivers and sea water intrusion into coastal aquifers
6. Sub-marine flows

Broadly, the Andhra Pradesh coast can be divided into four segments with characteristic features as detailed follow:

S.No.	Segment /Coastal Zone	Characteristic features
1.	Baruva-Bhimunipatnam	• Coastal neotectonics. • Enrichment of heavy mineral placers. • Holocene Red sediments. • Poor Socio-economic background.
2.	Visakhapatnam – Kakinada	• Influence of Coastal corridor, Exclusive Economic Zone and Coastal Industrial complexes • Breakwater induced shore dynamics and sediment transport. • Pollution due to industries and urbanization. • Influence of Tourism and marine sports. • Oil spill risk.
3.	Godavari – Krishna delta complex	• Coastal erosion : Kakinada- Uppada coast • Pollution due to irrigation return flows. • Extinction of Mangrove ecosystem. • Impact of Oil-well drilling. • Kolleru lake: Impact of aquaculture

4.	Nizampatnam – Nayudupeta	• Non-depositional areas- carbonate occurrences • Rich silica sands for glass industry • Pulicat lake: Biodiversity • Influence of salt industry

In addition to the above site specific issues vulnerability to natural hazards and non availability or accesses to time series scientific data on the coastal regions are perhaps the most critical issues to be addressed in coastal zone management at national level.

Easily accessible scientific data on coastal wetlands, land use, land forms, shore line and water quality are required periodically to ensure an environmentally effective coastal zone management practices.

In this context, to begin with, the Center for Studies on Bay of Bengal would like to launch a multi disciplinary, multi institutional collaborative research programme on Kakinada-Uppada coast and the Godavari sand spit.

Investigations contemplated in this programme will include studies on coastline changes with time and space, the seasonal influence of process response characteristics vis-à-vis shoreline migration and resources, identification and characterization of vulnerability regions, provenance and enrichment characteristics of heavy mineral beach placers, sea water intrusion into coastal aquifers and the socio-economic aspects of the coastal population and alternate livelihood in the light of diminishing coastal resources.

Proposed areas of research and collaboration with NCSCM

I. Research Programmes

1. Integrated studies on Kakinada-Uppada coast, Godavari sand spit and Kakinada bay towards a predictive coastal model.
2. Process-response characteristics of Kalingapatnam- Visakhapatnam Coast – A synergic approach.
3. Coastal Ecohydrology of Visakhapatnam coast- A perspective of seawater intrusion and submarine flows.

II. Capacity building

1. Coastal Oceanography: Basic concepts of coastal oceanography; Coastal and near shore processes; Dynamic behaviour of coastal regions; Sediment budget; Geological and Geophysical signatures responsible for field conditions and Application of Remote Sensing and Geographic Information Systems in the field of exploration, development and management of coastal region including living and non-living resources form an integral part of the training module.
2. Finishing School Concept in Coastal and Marine Sciences: This will be provided for the post graduate students after their graduation. This will be for a period of 6 weeks with extensive filed training and class room instruction.

III. Mass awareness programmes on coastal management

Importance of coastal zone and its resources management from scientific and socio-economic perspectives will be imparted to different groups of coastal population. The awareness /user-interaction will be conducted in different regions during different times of the year. Further, information sheets will be prepared and distributed to public during the awareness camps.

IV. Database

A Spatial Data Repository will be proposed to encompass the existing data and a Standard Data Model with a standard format need to be developed for marinating a National Data Repository. This can be taken up by the main centre at Chennai and ht collaborating institutions can participate.

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Context

The establishment of National Centre for Sustainable Coastal Management (NCSCM) under the World Bank assisted Integrated Coastal Zone Management Project of Ministry of Environment and Forests, Government of India at Anna University, Chennai fills a significant gap in the research and policy circles in India. NCSCM would facilitate inter-disciplinary research that is so essential for effective policy formulation in context of coastal development.

Madras School of Economics (MSE) is a designated Centre of Excellence in Environmental Economics by the Ministry of Environment and Forests and carries out policy relevant research on wide-range of issues related to natural resources and environment.

There is significant scope for collaborative research between NCSCM, especially the 'Integrated Social Sciences and Economics Division' (ISE) of the Centre, and MSE. This concept note provides a brief outline of the potential topics for collaborative research between ISE and MSE. Work along these lines could lay foundation for a long, sustained and fruitful interaction between these two Centres.

Objective

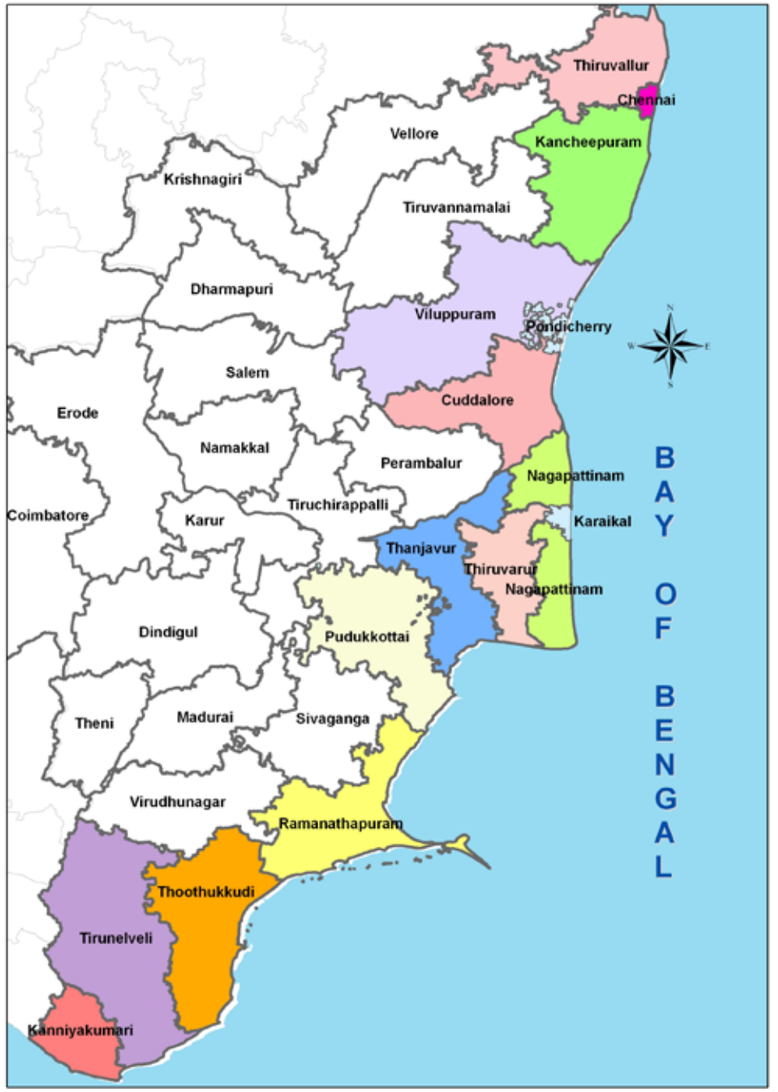
The objective of the collaborative research would be:

"Assessment of vulnerability of coastal regions in Tamil Nadu and building resilience using interactive governance framework"Towards meeting this objective the research would use the state-of-the-art modeling tools such as agent-based models and social network theory.

Brief Outline

The term 'vulnerability' as gained significant importance with the emergence of global climate change as a critical challenge. While the conceptualization of vulnerability within the climate change community is top-down in nature with climate change and sea level rise acting as the main drivers of vulnerability, other research communities such as development economics and natural hazards management follow place-based approach

COASTAL DISTRICTS OF TAMIL NADU



that is cognizant of the rich variety of social, cultural, economic, institutional and other factors that define vulnerability to famine or natural hazards. This complex nature of vulnerability is reflected in the definition of Downing et al. (1996): "Vulnerability is a complex and multidimensional social space defined by the determinate political, economic and institutional capabilities of people in specific places at specific times". Understanding vulnerability in these terms would facilitate identification of meaningful adaptation measures at the local scales.

One of the most important developments over the past thirty-plus years is the increasing recognition across the disciplines that human and ecological systems are interlinked and that their resilience relates to the functioning and interaction of the systems rather than to the stability of their components or the ability to maintain or return to some equilibrium state. The amalgamation of definitions of ecological, social and institutional resilience resulted in adoption of a broad definition of resilience with three dimensions (Carpenter et al., 2001):

- The amount of disturbance a system can absorb and still remain within the same state or domain of attraction;
- The degree to which the system is capable of self-organisation;
- The degree to which the system can build and increase the capacity for learning and adaptation.

While conceptually attractive, resilience is a difficult to operationalize notion. It is in this context adaptation (autonomous and planned) has emerged as an important policy tool for reducing vulnerability and enhancing resilience. Anticipatory (or, planned) adaptation is aimed at reducing a systems' vulnerability by either minimizing risk or maximizing adaptive capacity. Autonomous adaptation on the other hand will depend on the traditional knowledge of the system and ease with which information diffuses within the system.

Given the complex and dynamic interactions between the ecological, social and economic systems coastal regions offer significant scope for both autonomous and planned adaptations. Emerging tools such as agent-based modeling and network theory could have important role to play in identifying and implementing the effective adaptation options.

The agent-based modeling approach accounts for interactions between independent agents and their interactions with the surroundings. These parallel and local interactions give rise to path dependencies and dynamic returns. The agent-based models can be used to show how collective phenomena come about and how the interaction of the autonomous and heterogeneous agents leads to the emergence of such phenomena. These models can also help in the isolation of the criticial behaviour in order to identify the agents that drive the collective result. This is particularly relevant in the context of understanding the effectiveness of adaptation options

Similarly, given the close interaction between diverse agents operating in the coastal regions the network effects could be exploited to disseminate appropriate adaptation strategies.

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Coastal management issues before the people of Puducherry

The challenges confronting the coastal Puducherry are similar to the ones faced by the coastal cities in India. To wit:

- Pollution of the sea front due to municipal and industrial wastes.
- Ever-increasing demographic pressure with its attendant problems of waste generation and groundwater depletion – the latter causes salinity intension.
- Pressure on establishing hotels and amusement parks at the water front which would contribute to 'a' and 'b', above.
- Incomplete implementation of seasonal fishing bans, and overfishing.
- An increasingly intense conflict between developmental pressure and the health of the coastal environment.
- Beech erosion; destruction of mangroves.

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Primary issues of the coast of Pondicherry

1. Ground water depletion / pollution in coastal areas
2. Dumping of non segregated solid wastes
3. Poorly regulated tourism / industrial activities
4. Habitat degradation and biodiversity loss

Possible areas of research collaboration between our institution and NCSCM particularly on strengthening research - based on current coastal issues

1. Integrated coastal watershed management
2. Sustainable management of coastal solid wastes
3. Ecological land/water use planning for sustainable tourism /industrial ecological approaches towards ICZM
4. Co-management for coastal biodiversity conservation and sustainable livelihoods

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The State of Kerala lies along the southwest coast of India. It has a long seashore of 590 km and over 200,000 ha brackish water bodies. This spreads over 221 marine and 113 inland fishing villages. The density of population is one of the highest in the country the average density of the coastal area is over 2000 per sq. km. The coastal literacy rate is the highest in the country.

1. Resources

Kerala is resource rich. Fishery, heavy minerals, aesthetic beaches and cliffs of high tourism potential are great assets of Kerala coastal zone in addition to the abundance of quality human resource. Kerala's marine fish production is the largest in the country. This is in addition to the brackish water fishery. Though under exploited, the State has large potential for semi-intensive aquaculture including mussel and pearl culture. The beaches of Kerala are famous for its scenic beauty and the Government has declared beach and backwater tourism as one of the thrust area for economic development. Kerala coast has the richest deposits of heavy minerals in the country and its mining has generated many social and environmental issues.

2. Habitats

Kerala coast supports a variety of habitats. The mudbanks which are unique to this coast are one of the largest breeding and fishing grounds in the country. Kerala has at one time 70,000 ha mangroves which has now diminished to 1671 ha. Sandy beaches, lateritic & rocky cliffs, lagoons, kayals & estuaries and barrier islands are the characteristic features of this coast. Green Island (Dhrmadam Thuruth) is an uninhabited marine island which harbours a variety of marine organisms and is being threatened due to tourism related activities. The nesting sites of Olive Ridley turtle, one of the endangered turtle species, at the Kolavipalam beach on the northern coast of Kerala is facing threat of degradation due to human activities.

3. Issues and problems

The problems of the coastal zone are unique due to the high density of population, loss of land due to coastal erosion, mining of beach sand for industrial purposes, drastic morphological and shoreline changes due to shore structures like harbour breakwaters, destruction and reclamation of wetland including mangroves, saline intrusion into the water table, decreasing fish catch, development related degradation of the environment and violation of the provisions of CRZ. The coastal community is the only sector that periodically loses dwelling

places due to erosion. The destruction of natural habitats in the from of reclamation of wetlands, cutting of mangroves and dumping of industrial and urban wastes worsens the plight of the coastal communities.

The coastal zone of Kerala has large number structures such as seawalls, groynes and breakwaters. Seawalls have been constructed along more than 75% of the 590km shoreline. Alongwith the protection of the coast, this has caused loss of natural beaches and resulted in end erosion. Already 15 fishing harbours are completed or under construction. Anther 5 is in line. The breakwaters of these harbours have induced drastic shoreline changes along many coastal stretches of the State.

4. Major areas of collaboration with the NCSCM

Almost all the coastal systems, resources, habitats and socio economic issues are represented in the Kerala coastal zone. The well established decentralized planning-administrative system through Grama Panchayats and the high literacy rate provide the possibilities of effective grass-root level interventions to address various issues. Some of the possible areas of collaborative projects with NCSCZM are briefed below.

4.1 Coastal erosion studies

The coast requires alternate strategies with emphasis on soft measures to address the issue of coastal erosion. Coastal erosion and the present costal protection measures have resulted in the loss of beaches along a major part of the coast. The main aim should be to bring back the lost beaches to the coastal system.

The following could be of immediate priority: The data collection, assimilation and presentation need to be in digital platform with accurate GPS support. Care should be taken to see that the proposed studies are complementary to many of the ongoing studies undertaken by various agencies.

1. Identification of sediment cells based on coastal morphology, landforms, coastal processes and artificial structures/morphology
2. Segmentation of the coast based on erosion status and morphological units as high, medium, low and stable coast. Long term (50yr), short term/recent (the last 10 years as 2 segments of 5 years) and the current (last 2 years) erosion trends
3. Impact of shoreline structures such as seawalls and harbour breakwaters on coastal stability
4. Extraction of the present shoreline and its segmentwise orientation from high resolution imagery at a scale of 1:10,000 with accurate and precise georeferencing.
5. The above information could form input to Shoreline Management Plans for sustaining the natural beach system.

4.2 Coastal ecosystems

1. GPS Mapping of recent mudbank locations, tracking of mudbank migration during the last 50 yrs, morphological modifications due to mudbank formation and migration

2. Mapping of sensitive and ecologically fragile coastal ecosystems such as mangroves, sane dunes, mudflats, etc. to get their actual location, spatial extent and the current status.
3. These could be part of management plans for the sensitive coastal ecosystems (CRZ I)

4.3 Barrier islands & back water islands

1. The barrier beaches & backwater islands of Kerala are very sensitive environmentally, socially and economically as a large population depends on the system. The communities in most of such island systems are ecosystem people who depend on the natural island system for their survival. The distribution, extent, enviro-physico features and socio-economic-legal aspects of these islands need to be synthesised to support the development and environmental issues of their ecosystem people. Studies, which could support the local bodies to develop their management plans, could be taken up as multi-institutional programmes.
2. Major economically active zones
3. Major economic activity areas like tourism, fishery, heavy mineral mining, urban settlements could be zonated for further programmes for environment management action plans

Hazard mapping and CZM management plans for CRZ

1. Collaborative programmes on Hazard mapping
2. Provide support for CZM plans in connection with CRZ implementation
3. Provide support for mapping CRZ violations

COLLEGE OF FISHERIES MANGALORE, KARNATAKA

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Karnataka's coast stretches for 320 kilometres along the three districts of Dakshina Kannada, Udupi and Uttara Kannada. Of these, Uttara Kannada has 160-kilometre long coastline while 98 kilometres are in Udupi district and the rest in Dakshina Kannada. It's three distinct agro-climatic zones range from coastal flatlands in the west with undulating hills and valleys in the middle and high hill ranges in the east that separates it from the peninsula. There is a narrow strip of coastal plains with varying width between the mountain and the Arabian Sea, the average width being about 20 km. The average height of the hinterland is 70 - 75 meters, but in some places it can be as high as 150 meters.

Fourteen rivers drain their waters into the shore waters of Karnataka. The important estuaries include Netravati-Gurpur, Mulki, Hangarkatta, Gangolli, Sharavathi, Aghanashini, Gangavali and Kalinadi. Sand bars have developed in most of the estuaries. There are a number of barrier spits at Tannirbavi, Sasihitlu, Udyavara, Hoode, Hangarkatta and Kirimanjeshwara formed due to migration of coastal rivers. There are about 90 beaches with varying aesthetic potential that are suitable for beach tourism.

Issues

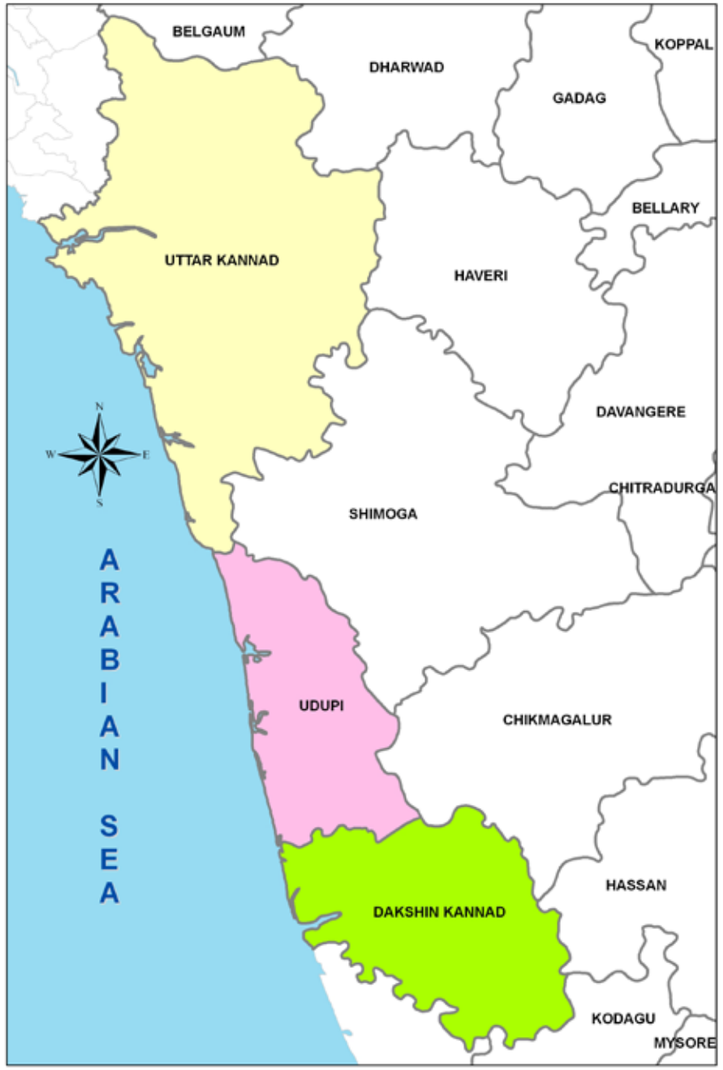
The coastal zone of Karnataka is one of the better-developed geographical areas of the State with high degree of economic development and density of population.
Occupational pressure

The settlements in the coastal region consist of 22 urban agglomerations and 1044 villages. The occupational pressure of the region can be attributed to agricultural activities, aquaculture, fish landing and processing, port maintenance, mining for lime shell, bauxite and silica sand and coir retting. The population density of Mangalore and Udupi taluks are 1048 persons per sq.km and 572 persons per sq.km respectively. The occupational pressure is likely to be increased in the urban areas of Mangalore and Udupi regions.

Coastal erosion

The Karnataka coast is subjected to three types of erosion; occurring along the open beaches, mouths of rivers/ estuaries and the tidal reach of rivers causing considerable loss of land, vegetation and revenue.
About 30 percent of the area under coastal zone is subjected to moderate soil erosion and 16 percent of the area to severe soil erosion. The annual rates of soil erosion vary from 5-15 tons/hectare to 15-40 tons/hectare

COASTAL DISTRICTS OF KARNATAKA



in moderate to severe soil erosion areas. The problem is relatively more severe in Dakshina Kannada and Udupi coasts. The erosion becomes severe due to the synchronization of high flood in the river with strong wave activity during southwest monsoon. The most affected locations are Kundapur Kodi, Hangarkatta and Bengre. Erosion/bank collapse in the tidal reaches of river is also severe and extends at least to about 12 kilometers. This has been noticed in Haladi River, Sitanadi near Mabukal and Ullal side of Netravathi riverbank.

Water pollution

The littering at beaches is very high and there is no mechanism for garbage disposal. The solid waste-dumping yard of Mangalore city has an area of 28.32 hectares, which is poorly managed. It is estimated that about 300 tons per day solid waste is generated in the Mangalore city of which 200 tons per day is collected and disposed into landfill. At Udupi, the solid waste generation is of the order of 8 tons per day of which 5 tons per day is disposed at unsecured landfill with an area of six acres. The unscientific disposal of the solid waste is the cause with all the other towns as well. Poor sanitary conditions have been observed in all the fish landing centres and fishing villages.

The near shore and estuarine waters are subjected to pollution due to various reasons such as inadequate sanitary measures in adjacent areas, port activities, effluent discharge from industries, dumping of fish wastes etc. The marine pollution here generally extends upto 5 kilometers and rarely upto 10 kilometers from the shore. The nutrient content and the coliform counts are relatively high in estuarine waters. Bioaccumulation of pollutants in aquatic organisms, such as Perna viridis,and Villorita cyprinoids etc are noticed.

Salinity

The intrusion of saline water in wells upto a distance of 1 kilometer from coastline in sandy areas and up to 500 meters from the tidal tract of estuaries in alluvial areas during summer also poses problems for drinking water availability. The coastal alluvial aquifers are highly permeable and are in hydraulic continuity with sea / estuarine water. Therefore, indiscriminate pumping from wells here leads to salinity intrusion. The high level of ground water exploitation and pumping the coastal zone, accentuates the problem. The intrusion of saline water into ground water aquifers and the ingression of seawater to the rivers/estuaries are adversely affecting the availability of potable water, especially during dry season.

Unsustainable fishing practices

The commercially important fishes in the sea around Karnataka are soil sardine, mackerel, catfishes, penaeid prawns, sharks, seer fishes, anchoivies and other clupiods, squill and squids. Karnataka has a shelf area of 25,000 square kilometers of which 7,000 square kilometers with water depth up to 50 m are extensively exploited for marine fisheries. The state contributes about 10 percent of the total marine fish landing in the country. There has been substantial increase in the use of trawlers in recent years. In the year 2004-05, altogether about 5500 trawl nets and 425 purse-seine nets have been used. On an average, about 82 percent of the total catch is

harvested using purs-seine (27 percent) and trawl nets (55 percent). The purse-seine net method targets an identified shoal and the trawl activity leads to scooping of the sea bottom. Selective scooping by trawl nets has exerted tremendous pressure on benthic organisms and their survival as these are thrown overboard and are discarded.

Causes

Unplanned development in urban areas and industrial locations leads to undesirable landuse practices. The removal of clay from riverbanks and alluvial plains to the tune of 32 lakh tons/year and laterite and hard rocks to the tune of 24-lakh tons/year adversely affect the carrying capacity of land. Similarly silica and sand mining to the tune of 1.5 lakh tons/annum and beach and river sand mining also contribute to the problem. Expanding infrastructure facilities lead to conversion of large tract of agricultural land to builtup areas. These are more pronounced in areas adjacent to industrial centers and fish landing centres. Conversion and reclamation of wetlands is causing estuarine biodiversity loss.

The concentration industries and the direct or indirect disposal of industrial disposal of industrial effluents and municipal drains to estuaries, rivers or nearshore waters cause water pollution. The haphazard dumping of fish waters near fish landing centres, processing of fish catch and the large number of ice factories (about 200) also cause water pollution. Improper solid waste disposal and inadequate treatment of sewage contribute to the water pollution in urban areas. The Netravathi and Gurpur estuarine rivers are considerably affected by the discharge of sewage from Mangalore city. Though rainfall in the coastal zone is heavy, about 88 percent of it is received during four months leading to disproportionate run off. This, in turn, reduces the flow in rivers during non-rainy periods, and hinders proper flushing. Excessive siltation consequently raises the riverbed. The reduced flow enhances the saline water intrusion to far upsteam. Increased salinity in the river stretches affects wells in the vicinity and alluvial tracts. Increased pumping in coastal sandy areas lead to landward movement of saline water-fresh water interface and up coming of saline water in dug wells.

While extracting ground water, specified spacing between wells is not maintained and no consideration given to sustainable yield causing over exploitation, natural interference of wells, and deterioration of quality in sandy and alluvial tracts and lowering of water table in laterite aquifers. The problem is compounded by drawl of water in large quantities by major industrial establishments and about 10,000 small-scale industries including about 200 ice factories.
The excessive siltation is mainly due to poor catchment conservation and increased sediment discharge of the respective rivers and improper flushing. The sediment discharge in rivers is accentuated due to the moderate to severe soil erosion of the order of 5-40 tons/hectare/year in respective catchment areas.

Coastal erosion is caused due to both natural processes and anthropogenic interventions. The unceasing act of winds, waves, tides and currents leads to shore movement or littoral drift along certain coastal stretches. The imbalance created or the lack of littoral material supply thus makes the land lose by erosion, which, at places will be permanent. The concentration of wave energy due to wave refraction further accelerates erosion.

Anthropogenic interventions such as coastal protection structures, breakwaters, dredging in harbors, silt traps/ dams in upstream portions of rivers, removal of sand from the beaches etc., often hinder the natural process beyond resilience limit and aggravate the problem of erosion. The flood flow in rivers flowing parallel to the coast makes the adjacent beaches more vulnerable to erosion.

The stress on marine fisheries is mainly due to the confinement of fishing activity to the nearshore zone upto a water depth of 50 meters. The increased use of trawl nets further accentuates degradation of fishery. Trawling results in disproportionate destruction of non-target groups along with juveniles and sub adults of desirable fishes and other benthic organism. Most of the by catches are of low economic value, but are vital for the food web consisting of marine shellfishes and finishes. By catches are thrown overboard. The discarded by catch include low valued ground fishes, crustaceans, anemones, sponges, echinoderms, jelly fishes, etc. besides the un markable juveniles of fish and shell fish.

Trends and Projections

The population pressure is expected to increase further due to urbanization and industrial development all along the coast. The pollution level in inland surface water increases during post monsoon and pre monsoon periods. The marine pollution will be a serious problem along Mangalore coast. The generation of waste in all the urban centres is expected to increase appreciably. In Mangalore, 25 percent increase in solid waste generation is expected over the next five years. In general, the water quality variation is cyclic. The excessive input of nutrients is leading to eutrophication in certain arms of the estuaries. The annual rate of increase in ground water exploitation is about 4 percent in Dakshina Kannada. By 2012 the projected level of ground water exploitation will be around 80 percent in Mangalore and Coondapur taluks and 90 percent in Udupi. The siltation is increasing in most of the river mouths/estuaries. However no quantitative estimate is available. The siltation is also high at New Mangalore Port Trust where the annual maintenance dredging varied from 1.67 million cubic meters during the last ten years. Intensive coastal erosion takes place from May end to middle of August, which is not continuous. The average recession of the beach during the two-year period (2000-05) in the southern part of the coast is 6.44 meters and the progradation in the northern part is 4.91 meters. Significant changes were observed in the LU/LC features of the study area. Built-up and forest area is increased by 1512.09 hectares and 697.95 hectares, respectively and habitation with vegetation and waste land area is decreased by 1142.48 hectares and 1052.16 hectares respectively. Area of submergence will be 87.44-km2 area of the total study area, if the water level in the Arabian Sea rises by 5m. Eight Coastal erosion vulnerable sites are identified in the study area, out of which Ullal is highly vulnerable. Effect of coastal structures along the coast is insignificant, as far as shoreline configuration is concerned. There is no large-scale erosion/deposition along this coast and the beaches are maintaining dynamic equilibrium.The marine fish production progressively increased up to 1996-97 (2,22,779 tons) and thereafter, showed a declining trend (1,52,500 tons in 2005-06) over the last five years the total cash return however, remained almost same. The trend indicates that the annual catch is getting stabilized around the estimated maximum sustainable yield. There is reduction in the population of several estuarine and marine organisms, including commercially important fish like the catfish.

Hotspots

The inventory and evaluation of the status of the resources and environmental quality based on secondary date enabled the identification of different hotspots with respect to major environmental issues of the ecosystem.

Occupational Pressure:	Urban centers of Mangalore and Udupi
Marine pollution:	Urban centers of Mangalore and Udupi, Baikampadi Industrial Estate and Panambur
Salt intrusion:	Nerthavathi, Pavanje and Udupi
Sea erosion:	Ullal, Thannirbhavi, Bengre, Sasihitlu, Udyavara, Coondapur, Kodi, Hangarakatta and Kirimanjeshwara
Siltation:	Netravathi and Gurpur rivers, Coondapur and Mulki ports
Unsustainable Fishing:	Dakshina Kannada Udupi coatcoast
CRZ Violation:	All along the coast

Major Areas of Research

1. Livelihood of coastal fishing communities
2. Coastal Pollution

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Over one third of the world's population lives either at the coasts or in adjacent coastal low land areas. Coastal lands and coastal waters comprise substantial quantities of the nation's agricultural, mineral and living resources. The coastal zone is characterized by a large variety of forms sandy beaches, rocky shores, river mouths, estuaries, lagoons, inter-tidal flats, wetlands and barrier islands, which have been shaped in the course of geological history. In and around these landforms, a number of specific biological communities have developed, including inter-tidal and marsh communities, mangroves, sea grass and coral reefs. Man has settled in the coastal zone for reasons such as easy accessibility, availability of basic facilities and abundance of food. The coastal zone is a scarce, vulnerable and dynamic territory, where natural, economic, demographic, social and environmental aspects come together. With the increase in population, its pressures on coastal zone in general, coastal resources in particular are rising. This can cause rapid decline in the quality of the coastal zone if no initiation is taken to conserve and manage.

India has about 7500 km long coastline. The coastline of India has been undergoing morphological changes throughout the geological past. The present coastal geomorphology of India has evolved largely in the background of the post – glacial transgression over the pre-existing topography of the coast and offshore. Goa a small state along west coast of India has about 100 km long coast and is characterized by pocket beaches flanked by rocky cliffs, estuaries, bays, and at some places mangroves. Beaches in southern Goa are long and linear in nature with sand dunes. The Mandovi and Zuari estuarine system in Goa is the largest in this part of the coast. Mud flats, swampy marshes and wetlands are found mainly along estuaries and creeks. The beaches of Goa are stable beaches with seasonal morphological changes and annual cyclicity.

The coastal zone in Goa is exposed to environmental and anthropogenic pressures. Some of the factors attributing to these pressures can be due to demographic settings and population growth, rapid urbanization, mining, migration, recreation and tourism activities, fishery activities, transportation problems, socio-economic shift and transformation in occupation like, fishing, tourism, trade, salt industry; wetlands conversion, degradation of agriculture land and fallow lands. In addition, social, financial issues and anti social activities are also the factors. The environmental issues are erosion at Anjuna and Kerim beaches, seasonal erosion during monsoon in several parts of the coastal stretch including headlands, garbage and sewerage disposal, mining waste, indiscriminate tapping of ground water resources, violations of the CRZ notification, establishment of unplanned aquaculture ponds, salt inundation in Khazan lands, eutrophication and encroachments in wetlands and agriculture land rendered fallow. The coastal zone in Goa contains habitats and ecosystems, such as, estuaries, mangroves and is entailed with a galaxy of resources, which have definite role in the maintenance of the ecological balance and

economic vitality of the coastal region. Climate change and associated sea level rise can be disastrous to small state like Goa. The understanding of coastal system in macro as a whole would therefore need to address these issues coupled with the social and economic fabric of the zone under question. It is now realized that uncontrolled activities either on the waterfront or beyond or on the land-based side could cause irreversible damage to the ecosystem. Moreover the developmental activities that ignore the dynamics of the coastal system can be catastrophic as evidenced by the increasing loss of lives, property and investment due to coastal flooding and erosion.

It is evident that the multitude of increasing pressures on the coastal systems, coastal wetland transformation and ecological stress on the estuaries is posing a threat to the human population and the coastal resources. In this context, and so as to ensure that these ecosystems maintain their ecological, productive and natural functions, a detailed coastal zone resource information system is a prerequisite. In order to achieve sustainable development, it is important to have strategies such as, conserving and enhancing the coastal environment, managing risks and coastal vulnerability and merging coastal environmental considerations with economic decision through the mechanism of a comprehensive Coastal Zone Management Plan.

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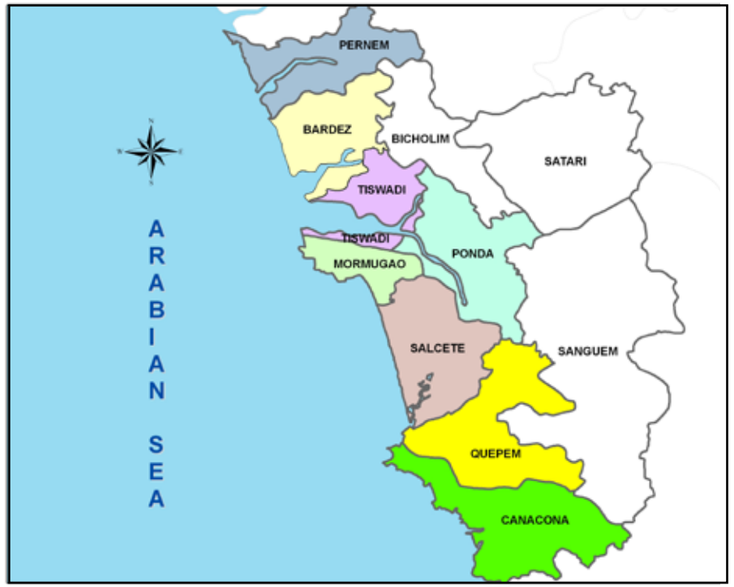
COASTAL DISTRICTS OF GOA



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1. Background

The Ministry of Environment and Forests (MoEF), Government of India, is establishing a World Class National Centre for Sustainable Coastal Management (NCSCM) under the above project within Anna University Chennai.

The Centre shall serve as a policy-guiding R&D institution with a central repository of information and knowledge on the coast for its management. The NCSCM would conduct scientific research in multiple fields concerning integrated coastal management and would function under the Ministry of Environment and Forests (MOEF), Government of India, to advise the government and other stakeholders on science, policy and legal matters related to coastal management. The NCSCM would serve as an impartial neutral interface between coastal communities, experts and governments, and promote applied research, education and awareness including ecological literacy with respect to coastal management.

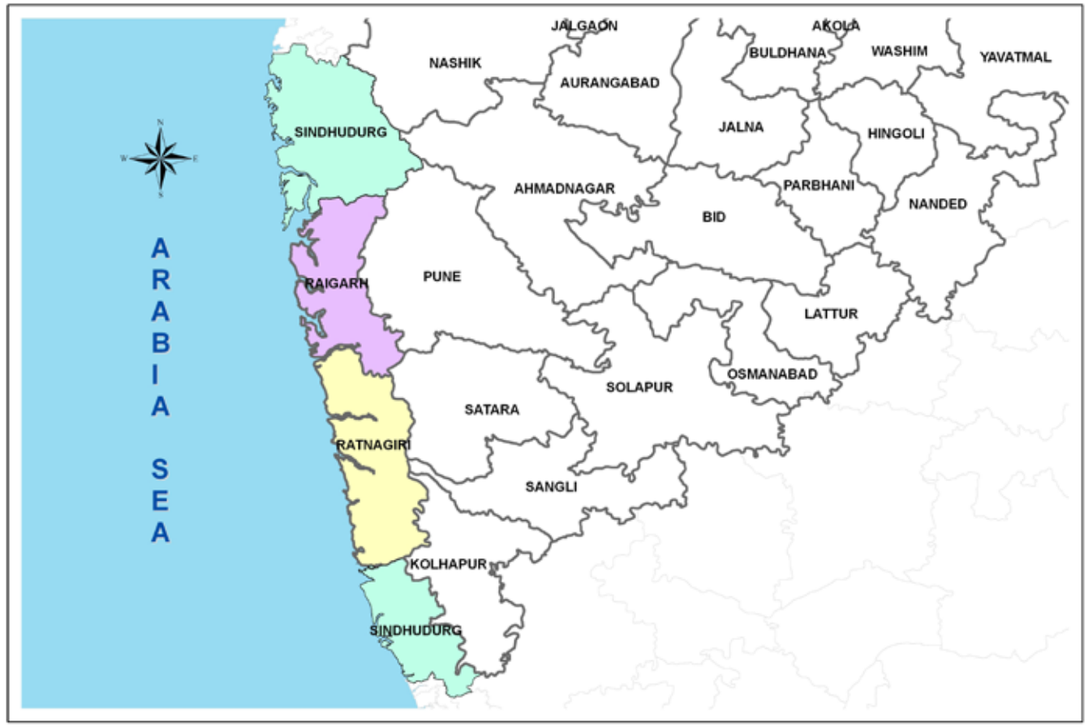
The Centre has the following six major divisions to execute various projects of national and international importance:

- Geospatial Sciences Division (GEO)
- Integrated Social Sciences & Economics Division (ISE)
- Coastal/ Marine Environment Impact Assessment Division (CIA)
- Conservation of Coastal and Marine Resources Division (CMR)
- Knowledge, Governance and Policy Division (KGP)
- Futuristic Research Division (FTR)

The Centre proposes to have collaborating centres/agencies in each of the coastal State and Union territories. These collaborating centres/agencies shall be responsible for undertaking area specific scientific research in the area of coastal management including addressing issues of coastal communities.

The Ministry has identified Dr. Sanjay V. Deshmukh, Professor of Life Sciences and Head, University Department of Life Sciences as one of the collaborating Centres of the NCSCM. NCSCM shall work with University Department of Life Sciences on some of the specific issues from the above-said Theme Areas. The NCSCM will provide technical and financial support to each of the collaborating centres/agencies based on a proposal that would be drawn up by University Department of Life Sciences.

COASTAL DISTRICTS OF MAHARASTRA



Following pages highlight various issues concerning conservation and sustainable management of coastal Maharashtra and also activities to be carried out by the proposed Maharashtra State Centre for Sustainable Coastal Management (MSCSCM), to be established under the auspices of National Centre for Sustainable Coastal Management (NCSCM)

2. India's biological resources

India is a nation of extraordinary diversity, the seventh largest and the second with respect to the population number, in the world. Its relief can be conceptualised in terms of three well-defined regions: the Himalayan mountain system along its northern margin; the Gangetic Plain, which extends some 2,400km from Assam in the east to the Punjab in the west and southwards to the Rann of Kutchchh in Gujarat; and the Deccan Plateau which is flanked on either side by the Western Ghats and Eastern Ghats (Mani, 1974). Its rich diversity of ecosystems, which range from tropical rain forests to deserts, and from marine and coastal systems to high mountains, support an estimated 5-8% of the world's known flowering plant and animal species, of which a significant proportion are endemic (Gadgil and Meher-Homji, 1986a). Important centres of biological diversity, particularly for plants, are the Western Ghats, North-eastern India and the Andaman and Nicobar Islands (Nayar, 1989).

The total area of wetlands (excluding rivers) in India is 58,286,000ha, or 18.4% of the country, 70% of which comprises areas under paddy cultivation. A total of 1,193 wetlands, covering an area of 3,904,543ha, were recorded in a preliminary inventory coordinated by the Department of Science and Technology, of which 572 were natural. In a recent review of India's wetlands, 93 are identified as being of conservation importance (Scott, 1989).

Coral reefs occur along only a few sections of the mainland, principally the Gulf of Kutchchh, off the southern mainland coast, and around a number of islands opposite Sri Lanka. This general absence is due largely to the presence of major river systems and the sedimentary regime on the continental shelf. Elsewhere, corals are also found in the Andaman, Nicobar and Lakshadweep groups, although their diversity is reported to be lower than in south-east India (UNEP/IUCN, 1988).

2.1. Maharashtra coast

The Maharashtra coast (popularly known as Konkan) harbours a significant diversity of natural resources. This region has endowed with number of natural and man made assets that have attracted attention of scientists and communities. Konkan constitute a narrow belt between the western mountain range (regionally known as Western Ghats) and Arabian Sea. It stretches about 720 km from the River Tapi in the north up to the River Terekhol in the south and encompasses six districts viz. Thane, Greater Mumbai, Mumbai, Raigad (former Colaba), Ratnagiri and Sindhudurg (previously under Ratnagiri). The coastal zone of Maharashtra extends from 15°43'N and 20°10'N and longitude between 72°39'E and 73°30'E. The coastline is indented by numerous river mouths, creeks, small bays, headlands, sandy and rocky beaches, promontories, cliffs etc. In the north of Mumbai it is wide up to 100 km, which gradually decreases towards south and near Vengurla, it is hardly 40 km. The coast is indented with number of beaches, 15 rivers, 5 major estuaries and over 30 backwater regions. According to

the surveys by the State Government agency, the total area of all the coastal districts is 30645.5 Km2 comprising built up land (1.58%), agricultural (44.14%), forests (19.48%), wastelands (28.72%), waterbodies (4.13%) and land under grasslands, mining areas and saltpans (1.95%).

3. Coastal and Marine Biodiversity: Threats and conservation status:

Among natural threats, storms and waves particularly cyclones are major stresses on marine ecosystems. Impacts of tsunami on various sites of marine ecosystems in India were devastating. Varied human activities which are a cause for concern over and above the natural disturbances include: runoff and sedimentation from developmental activities (projects), eutrophication from sewage and agriculture, physical impact of maritime activities, dredging, destructive fishing practices, pollution from industrial sources and oil refineries of anthropogenic disturbances.

- Fishing is a major activity in the fishing villages situated along the 8,000 km coastline of India. About one million people are occupied full time in marine capture fisheries. Commercial and unsustainable fishing activities pose a threat to marine biodiversity.

India has over 32 marine and coastal PAs covering intertidal/sub-tidal or seawater-mangroves, coral reefs, lagoons, estuaries, beaches, etc. Besides, another 100 PAs have terrestrial and fresh water ecosystems which constitute boundaries with sea water or partly contain marine environment. In addition, there are four BRs in the marine and coastal environs.

- WPA provides for protection of marine species and coral reefs.
- India's CRZ Notification, 1991 under the EPA regulates onshore development activities which affect coastal environments.

3.1 Coastal area issues

The widely increasing pollution problems, extensive destruction and modification of marine habitats in the interests, called economic development, and the prodigious over-exploitation of renewable resources are definite indications of our heading towards a point of no return in many areas of our country, without concern for the future. Rapid mechanisation processes in the exploitation of marine living and non-living resources with increasing industrial involvement have added to the plethora of difficulties. Because of the conflict of uses in the coastal zone, coast-related island systems and surrounding habitats, many facets of the marine ecosystem and habitats are being increasingly tampered with activities such as commercial fishing, navigation, energy exploitation, national defence, recreation and quarrying for industrial needs.

3.1.1. Coastal Erosion

All Indian maritime states and union territories are subject to varying degrees of coastal erosion. Approximately 1,450 kilometres (km) or about 26% of the country's mainland coastline is prone to erosion, causing an estimated loss of about 450 hectares (ha) of land each year. Around 20–25% of India's population lives within 50 km of the coast and around 70% of those people are in rural areas. It is these rural poor coastal communities who are the most vulnerable to the impacts of erosion.

Many of India's rapidly growing urban areas are also vulnerable to coastal erosion; Mumbai, for example, incurs a cost of approximately $2.5 million per km on capital works alone to protect some of its prime waterfront property. The impact of climate change is likely to aggravate coastal erosion even further. Sea level rise in the Indian subcontinent is projected to be between 15 and 38 centimetres (cm) by the middle of the 21st century, rising to between 46 and 59 cm by the end of the century. A 1 meter (m) rise in sea level in India would inundate about 5,700 square kilometres (km2) of land, affecting around 7 million people.

3.1.2. Financial Issues Relating to Coastal Protection

In 1991–1992, investment in erosion mitigation suffered a setback due to the cessation of central loan assistance. Constrained by limited funds, state government investment in coastal protection measures has declined, and funds have often been inadequate to address even urgent coastal protection works.

3.1.3. Institutional Issues Relating to Coastal Protection

The mandate for coastal erosion mitigation is typically entrusted to a coastal division, which is subsumed within a larger state department with a much broader mandate. Consequently, the budget for coastal protection measures is also subsumed within broader budget areas (such as roads, port development, flood control, and irrigation). Similarly, the technical and human-resource capacity of the coastal divisions is limited which subsequently hampers the implementation of sustainable coastal protection measures.

3.1.4. Coastal Protection and Coastal Zone Management

Coastal erosion mitigation is integrally linked with coastal zone management. Hence it would only be apt if coastal protection measures are incorporated into such integrated coastal zone management plans. However, the preparation and effective implementation of ecologically sustainable coastal zone management plans is a long-term measure. Hence, priority coastal protection measures and other development activities along the coastal zone will need to be undertaken in parallel with the introduction of the coastal zone planning process.

4. Issues Specific to Maharashtra

4.1. Coastal regions

Maharashtra has a coastline of 720 km, of which about 320 km (about 44%) is subject to erosion. Coastal urban areas such as Mumbai have been severely affected by erosion, partly due to clearance of mangroves and associated vegetation along the shoreline and also due to construction of offshore and coastal infrastructure. Rural coastal regions are hence adversely affected by erosion. This has increased the vulnerability of resident coastal communities to natural disasters (such as cyclones) since their dwellings are along the fringes of the shoreline. The government of Maharashtra recognizes the need to address coastal protection in a more systematic manner. The state is interested in identifying alternative coastal protection methods that are compatible with the coastal activities and the environments that are to be protected, particularly innovative coastal protection interventions that can be structured into financially viable projects, especially through public–private partnerships.

4.2. Mangrove and related ecosystems

4.1. Threats to the mangroves of MaharashtrA

The diversity and distribution of mangroves along the Konkan coast indicates the sensitivity of mangroves to various environmental changes. On the same lines, biotic threats to this fragile ecosystem along the coast were identified and analyzed. The increasing anthropogenic pressures, in the form of conversion of habitats or pollution, are responsible for the decline in species level diversity of mangroves along the coast.

In Thane district, industrial expansion is the significant cause for mangrove swamp conversion. The present floristic diversity in the northern coast of Maharashtra shows that species like Lumnitzera racemosa, Bruguiera parviflora recorded by the earlier workers have become locally extinct. Overall, the zonation pattern in the mangroves of Maharashtra is highly influenced by human interference and rarely there are patches showing natural zonation. On the contrary, threat resistant and opportunistic species grow luxuriantly and dominate the mangrove forests. These threats can broadly be classified into direct biotic interference and indirect activity like pollution. Representative threats are highlighted below:

4.1.1. Biotic threats

4.1.1.1. Moth infestation

A common teak defoliator Hyblaea puera (Lepidoptera Hyblaeidae) was found to infest Avicennia marina in and around Mumbai region and adjoining districts such as Thane and Raigad. In 1999, the area affected was 450 ha along the Thane creek. In 2002, more than 4000 ha and in 2008, about 6000 of mangroves were affected by this moth infestation.

4.1.1.2. Barnacles infestation

The aerial roots of Rhizophora, Bruguiera and pneumatophores of Sonneratia were found to be colonized by the barnacles especially near rocky habitats

4.1.1.3. Grazing

The natural regeneration and plantations of mangroves are subject to grazing. Being a part of common property lands, the cattle graze freely on mangrove swamps. Avicennia marina is the most preferred plant species by grazing animals.

4.1.2. Anthropogenic interference

4.1.2.1. Wood felling

Clearing of mangrove trees from swamps renders it an irreversible change to the landform. Woody mangrove species are frequently utilized for fuel and low quality timber product in Maharashtra.

4.1.2.2. Agriculture

Leaves of Avicennia and Aegiceras sp. are commonly used for the slash and burn technique. In this method, the leafy branches are chopped out from the healthy plants and used for burning in the agricultural fields (mostly paddy) in order to enrich the nutrient content of the soil. This is a common practice in Thane and Raigad districts.

4.1.2.3. Dumping of non-biodegradable solid wastes

Regions along the Thane, and Mahim Creeks show high values of industrial and domestic solid waste accumulation in the mangrove swamps. In fact, different types of plastic material cover most of the mud flats and mangrove areas. This situation is common along the coastal Ratnagiri District where industrial estates are located (e.g., Chiplun, Ratnagiri, etc.)

4.1.2.3. Water pollution

Pollution of the brackish water due to the industrial and sewerage discharge is serious along the coastal belt of Maharashtra. Increasing urbanization in the densely populated cities like Thane, Mumbai or fast developing cities like Alibag, Ratnagiri, Malwan is responsible for generation of huge quantities of sewage and disposal problems. Series of Industrial belts developed along Dahanu-Tarapur (Thane), Thane-Belapur (Mumbai), Alibag-Roha (Raigad), Lote Parshuram (Ratnagiri) has resulted in increased industrial effluents.

4.1.3. Conversion of mangrove swamps

Mangrove swamps are often transformed for various purposes like aquaculture, agriculture, extension of residential, industrial or related developmental campuses. Of this, conversions to aquaculture or saltpans can be considered as reversible changes. But permanent land filling activity will change the properties of these swamps and lead to irreversible changes.

4.1.3.1. Conversion into saltpans

The temperatures and wind conditions prevailing along the northern coastline of Maharashtra are congenial for several saltpan activities. Traditionally the mangrove swamps were converted in to the saltpans in Thane and Mumbai. The saltpans provide livelihood for a large number of unskilled workers and also the raw material for several other industries. Nevertheless, there are adverse impacts of the saltpan activities including salinity ingress into groundwater and associated occupational health hazards.

4.1.3.2. Conversion into aquaculture plots

Worldwide, the conversion of mangrove land into aquaculture appears to be a serious threat. Along the Maharashtra coast, most mangrove swamps are converted for mariculture in Raigad district by private entrepreneurs. Most of these privately owned plots along the Ratnagiri and Sindhudurg coast are now abandoned because of commercial failure. The owners are unable to find beneficial market chains for the products.

4.1.3.3. Conversion into agricultural plots

Mangrove swamps are generally marginal for agriculture, yet conversion of mangrove land for agriculture is widespread. The increasing population in the coastal districts is exerting a tremendous pressure on the limited agricultural land. Along the Maharashtra coast, construction of dykes in the intertidal regions and conversion of mangrove areas in to rice fields is one of the major threats for mangrove forests.

4.1.3.4. Conversion into residential / industrial plots

Conversion of mangrove swamps into residential plots is observed in vicinity of fast growing cities like Mumbai. In these cities, chances for horizontal expansion are meagre for residential or industrial premises. In such cases mangrove swamps are reclaimed on larger scale for this purpose.

Except few cases in Mumbai, quantification of all such conversions have not been attempted and there is an urgent need to use high resolution remote data to know such developmental pressures on the mangrove ecosystem for their conservation and management.

5. Government initiatives in conservation of coastal biodiversity

Based on the earlier surveys conducted by various Organisations such as BNHS (Mumbai), Manav Sadhan Vikas Snastha (Mumbai), National Institute of Oceanography (Goa) along the West Coast of Maharashtra and their recommendations, the State Department of Forests has identified the Marine Protected Areas (MPA) of Maharashtra state that can be treated as 'Regional Hotspots of coastal Maharashtra'. Important criteria adopted for identifying such sites are based on the following parameters:

- Status of the ecosystem
- Economic importance and genetic variation
- Endemism
- Human relation in terms of resource usage.

Based on this study ten sites along the Maharashtra Coast have been identified for MPA programme. They are:

- Achra-Ratnagiri
- Devgad-Vijaydurg,
- Veldur
- Kundalika-Ravdanda
- Mumbra-Diva
- Vikhroli
- Shreevardhan
- Vaitarna
- Vasai-Manori
- Malvan.

6. Proposed Activities of Maharashtra Centre of NCSCM

The Ministry has identified Dr. Sanjay V. Deshmukh, Professor of Life Sciences and Head, University Department of Life Sciences, University of Mumbai as one of the collaborating Centres of the NCSCM. It is proposed that the Maharashtra State Centre for Sustainable Coastal Management (MSCSCM) shall be housed at the University Department of Life Sciences, University of Mumbai and would function under the overall guidance of NCSCM on the specific issues from the following Theme Areas:

6.1. Geospatial Sciences Division (GEO)

- Mapping with the help of remote sensing devices, coastal land use (change detection over time intervals) as well as coastal structures. Emphasis would be placed on critically vulnerable coastal areas such as mangroves, coral reefs, sea grasses and other ecologically sensitive coastal ecosystems.

6.2. Integrated Social Sciences & Economics Division (ISE)

- Valuing biological diversity in natural resources rich coastal stretches of Maharashtra, by application of Environmental Economics Techniques;
- Addressing gender-based issues in utilisation of coastal resources and to enhance resilience in the advent of climate change issues;
- Identify interventions (training/ entrepreneurship development) based on analysis of various environmental and social issues such as sea level rise/climate change/ changes in coastal fisheries / turning off freshwater flow to estuaries / causes and consequences in changes of human wellbeing.

6.3. Coastal/ Marine Environment Impact Assessment Division (CIA)

- Study of impacts of developmental processes (such as megaprojects) by undertaking short and long term ecosystem assessment;

6.4. Conservation of Coastal and Marine Resources Division (CMR)

- Participatory coastal and marine resources management
- Development of a Portal on various issues of coastal and marine resources such as (a) biodiversity documentation; (b) location specific coastal health monitoring; (c) study pollution impacts and

6.5. Knowledge, Governance and Policy Division (KGP)

- Develop policies for conservation of biodiversity-rich coastal and marine areas as well as islands regions;
- Special emphasis would be placed on conservation of Heritage Islands such as Elephanta Island, and biodiversity conservation of archaeological sites such as coastal Forts;
- Initiate new academic courses (e.g., Certificate, Diploma, Degree) relating to Sustainable Coastal Management. Beginning could be made by initiating implementation of Marine Biotechnology M.Tech. Programme initiated by Centre for Ocean Management, Anna University at University of Mumbai.

6.6. Futuristic Research Division (FTR)

Initiate anticipatory research on coastal and marine resources (such as identification of candidate genes from mangroves, sea grasses, marine fungi and other biological organisms) that would help provide solutions to the problem of climate change.

The Centre will operate simultaneously along two parallel paths: (i) it will seek to develop a sustainable (long-term) planning and management process for Sustainable Coastal Management and (ii) it will address urgent (short-to-medium term) Coastal Management requirements of Maharashtra. The Centre will seek to integrate

the two outputs, thereby guiding state authorities to eventually adopt sustainable long-term sustainable coastal management strategies.

7. Approach to implementation

Following two approaches would be adopted for successful initiation of the Centre.

7.1. Approach 1

Planning, Institutional Development, and Investment Planning: The Maharashtra State Centre for Sustainable Coastal Management (MSCSCM) shall will review coastal protection measures adopted by the participating States, including ongoing interventions, policy and institutional frameworks, current strategies, and investment and funding plans. Based on the review by NCSCM, a design framework for sustainable long-term sustainable coastal management will be prepared to cover each stage of the process from planning, financing, implementation, and enforcement, to monitoring and evaluation. Thereafter, action and investment plans will be prepared to enhance each of the stages mentioned above. Action plans will cover institutional development and capacity building at the state level, and investment plans will cover specific interventions for each stage.

Finally, outcome of the action and investment plans will be packaged into a National Strategy covering all the maritime States.

7.2. Approach 2

Detailed Designs of specific Sites: The sites identified for implementation of strategies for Maharashtra will undergo a detailed design and feasibility analysis.

This will be followed by numerical modelling (to be carried out using an iterative approach) to design appropriate sustainable coastal management plan for each site together with the corresponding social and environmental impacts, associated costs, and detailed feasibility studies.

8. Cost and Financing

Detailed cost estimates and a financing plan would be developed in consultation with NCSCM on June 21, 2010.

Acknowledgement

The information provided in this document is derived from the research work conducted by various individuals and institutions on the coastal regions of Maharashtra. Noteworthy among them are:

- National Institute of Oceanography, Goa;
- Bombay Natural History Society (BNHS), Mumbai;
- Manav Sadhan Vikas Sanstha (MSVS), Mumbai;
- University of Mumbai, Mumbai;
- Prof. Sanjay V. Deshmukh;
- Dr. Mahesh Shindikar (PhD work).

The work of the above-mentioned agencies/ individuals is documented in various forms (reports, research papers, etc.) and is referred to arrive at the above version.

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Primary Issues of Gujarat Coast

Introduction

Gujarat State was formed in the year 1960 when the erstwhile bilingual Bombay State was split into two separate States, namely, Gujarati speaking Gujarat State and Marathi speaking Maharashtra State. With its enterprising population and committed leadership Gujarat has done well since then in terms of overall economic growth. It has progressed to acquire the fourth rank in per capita income among the major sixteen States in India and has maintained this rank for the last two decades or so. Today it is one of the prosperous states of India with about 50 million population spread over 196000 Sq. Km. Though the State has less than 5 per cent of the national population, it has 6.56 per cent of the national production and about 11 percent of the national industrial output. Gujarat is the only maritime state with longest (1650km) long sea coast in India of which 60% is distributed in two gulfs.

Environment and Ecology

The diversity has resulted in uneven distribution of land, water and vegetation in the state. Unfortunately the state has mismanaged these resources.

Man-made coastal issues

Man-made coastal issues are usually triggered due to reclamation of seaward side; effluent discharge into estuary areas; blocking of flow of water in delta regions; illegal mining from rivers; dredging activities resulting in high turbidity conditions; proliferation of ports, oil terminals, chemical industries; pipelines; coastal erosion due to heavy infrastructure construction including seawalls; oil pollution in sea due to oil refineries and from ships like oil tankers.

Ship-breaking units

The world's largest ship recycling yard at Alang, District Bhavnagar on the coast of Gulf of Khambhat and the second-largest shipbreaking unit in Gujarat is located at Sachana, under the ambit of the Bedi port close to MNP. Engine oil and other non-degradable toxic compounds flow into the protected waters of the Gulf of Kachch from where tides wash them into neighbouring creeks and mangrove swamps. Consequently, mangroves in the region are so degraded that they cannot be regenerated.

Ports and jetties

As the first Indian State to privatize its port sector, Gujarat revamped its port policy, allowing for massive private sector participation in port building and container handling capabilities. With the announcement of 10 greenfield sites for port development in 2007, the port sector attracted 19 memorandums of understanding (MoUs) with investments worth Rs.104.74 bn.

Currently, Gujarat has the highest number of ports in the country—41—and these handle 20 per cent of India's cargo. It is estimated that by the year 2015, cargo volumes at Gujarat's ports will grow to about 400 mn tpa - 39 per cent of the total national cargo volume.

There are many environmental problems associated with increased port development and maritime activity, including tanker spills and accidents, as well as sediment deposition on corals due to deep-sea dredging activities. The accelerated development of ports and harbours will also greatly increase the problems that fishing communities face, further restricting their fishing grounds and depleting the availability of fish.

Salinity Ingress

Salinity ingress is another serious environmental problem of the state. The saline area in the state increased more than 8 times during 1975-1993. This was primarily because of (a) the destruction of mangroves on the sea coast, (b) overdrafting of (sweet) ground water in the coastal regions and (c) overdrafting of ground water in other regions. The extent of salinity has increased also in canal irrigated area due to the over use of (cheap) canal water resulting in water logging in these regions. It has been estimated by the Gujarat Ecology Commission (GEC) that about 30% area of the state will be affected by excess salinity by 2001 AD if radical actions are not taken to control its ingress. The most damaged area will be the region around the Gulf of Khambhat and the coastal Saurashtra (GEC 1997).

Industrial Development

182 industrial estates in the state have industries like Agro-Processing, Dairy & Engg. Chem & Petrochem. Pharma, Textiles, Engg & Auto, Diamond processing, IT/BT/ Financial services DMIC Influence Area LNG Terminal, Key Ports, Soda Ash, Cement Petroleum, Minerals, Engg, Brass Parts, Engineering & Ceramics, Engg & Auto, Steel Pipes, Cement, Salt etc.

Pollution

Pollution due to industrial effluent discharge is a major issue in South Gujarat coast, especially in the Mindhola and Tapi estuary as well as in the coastal areas of Daman and Diu. This has led to health concerns and damage to fish breeding, fish growth and subsequently resulted in low fish catch.

Oil pollution from oil and gas surveys, offshore oil production, oil terminals, pipelines, ships, ports and single point mooring (SPM) activities are very high in South Gujarat sea. This has affected the marine and coastal ecology. The source for major oil spills in this area is usually not found out. Around 200 kms. Coastaline of South

Gujarat, Daman U.T. and Maharashtra are affected due to heavy oil spill. There are no oil spill contingency plans and resources available. Only the coast guard is responsible for monitoring such activities on the sea, which is inadequate.

Sand mining

Sand mining has led to affecting the water table in coastal areas as well as triggered salinity intrusion. There are numerous cases of illegal sand mining in estuarine areas of Ambika, Purna, Kaveri, Aurang river, Mindhola and Tapi estuary, and on the coast of Junagadh and Porbandar District.

Coastal erosion:

Coastal erosion is also a major problem in South Gujarat. Erosion rates between the Mindhola and Varoli estuary is almost 10m/year.

Many farmers have lost their agricultural land due to erosion aspects. Erosion also reduces the water availability in coastal aquifers and increases the salinity intrusion. Migration of coastal communities due to environmental degradation is a potential problem in South Gujarat and hence CRZ regulations must lead to protection of the habitat and livelihood of the coastal community. 70% of people from Bilimora and Gandevi village have migrated because of the coastal erosion.

Issues in Marine National Park, Jamnagar

Demarcation of boundaries

Although the MNPS was established for the conservation of marine resources, we have no information on the rationale used to demarcate the MNPS areas. The 1994 MNPS management plan too does not explain this. When the MNPS was declared, the area covered by the 42 islands in the Gulf of Kachchh was assessed to be 148.92 sq km. This figure was subsequently used to mark the MNPS boundaries. However, a study by the National Institute of Oceanography (NIO) points out that according to satellite-based wetland maps, the total area covered by the 42 islands

during low tides is actually 410.6 sq km; therefore, a major part of the islands (261.7 sq km), containing healthy coral reefs, are outside the legal boundaries of the MNPS, pointing to the need to redraw the MNPS boundaries30. Boundary settlement continues to be a contentious issue. According to the WLPA, once an area is declared as protected, the legal settlement of boundaries and the rights of local communities must be completed within a two-year time frame. However, as late as 1994, when the management plan for the MNPS was written, 12 years after the PAs were notified, 60 km of the territorial boundary line and 499 km of the boundaries of islands in the Gulf (the permanent water line) remained non-demarcated and under dispute. The Conservator of Forests, in charge of the MNPS areas, revealed that the problem emanated from the fact that when the MNPS areas were declared, the formal settlement of rights was never officially carried out, leading to a grave problem of overlapping jurisdiction that persists to date.

Tourism

The species diversity in the MNPS areas is being leveraged to promote tourism. In 2006- 07, about 7,000 tourists visited the Pirotan island, which is rich with fringing coral reefs and mangroves, and is part of the National Park's Core Area. The 1994 MNPS management plan had proposed that Pirotan be designated a Zone 1A Area, that is, an area under the highest protection within the MNPS, closed to all activity except scientific research, visits of pirs (sacred places) by fishers, and afforestation. However, zoning was never implemented, and, instead, the island was opened to tourism. MNPS authorities believe that only the serious and environmentally sensitive tourist would take the trouble

of visiting the remote island of Pirotan. Environmentalists in Jamnagar, however, claim that Pirotan's corals are already facing heavy damage as they often get crushed under the feet of visitors. As one environmentalist put it, "The tourist may be sensitive but his boots are not!"

Developmental Activities in the Region

India's economic liberalization programme, which gathered steam since 1991, has transformed Gujarat, the State with the longest coastline, well-developed ports and related infrastructure into the country's top investment destination. In 2006-07, Gujarat cornered about one-fourth of India's total industrial investment, with investments of Rs 73,170 crore from 86 projects. The State set itself an industrial output target of Rs.3680 billion by the year 2020, nearly seven times the existing level. Most of the investments were mopped up in the Gulf of Kachchh, bestowing the region with a new nickname, 'The Gulf of Riches'. If a new generation of billionaires was being spawned, it was, as a national daily declared, "all thanks to [the] Gulf of Kachchh".

As the areas within and around it become prime investment targets, the Gulf of Kachchh MNPS today faces unprecedented challenges, including the threat of de-notification.

The investments that are pouring into the Gulf of Kachchh region will essentially mean a much larger scale of the same kind of industrial development that the region has already experienced. The following sections, therefore, cover the impact of existing industries. The petroleum and petrochemicals industry receives a more detailed consideration for

two reasons: (a) over 50 per cent of new investments are in this sector; and (b) it is considered the biggest threat to the PAs in the region.

Petroleum and Petrochemicals

The Gulf of Kachchh, due to its proximity to oil-exporting Middle East countries, and the natural advantages of its calm ports, is emerging as a major oil-importing base and refinery site. Seventy per cent of India's total crude import is expected to take place through the Gulf of Kachchh; its oil traffic in 2007 was estimated to be about 84 million tones. As of November 2007, the Gulf had attracted investments worth Rs 1.40 lakh crores from four of India's billionaires - Mukesh Ambani, Shashi Ruia, Ratan Tata and Gautam Adani.

Until the 1990s, the Gulf of Kachchh had an annual refining capacity of less than 1 mn tonnes, all in the public sector. In the last decade, the area has seen a fifty-fold increase in refining capacity, to around 45 mn tonnes per annum.

Recent verdicts of the Supreme Court of India allowing oil companies like Reliance and Essar to lay oil pipelines right through the Gulf of Kachchh MNPS have been viewed as a severe setback to the conservation agenda. The court judgements have ruled that pipelines through Core Areas would not cause more than minimum or transient damage and, in fact, "ultimately would improve the habitat of both the Sanctuary as well as the National Park".
During the construction phase, offshore infrastructural activities such as the laying of pipelines, setting up a single buoy mooring (SBM), and constructing the product terminal can result in habitat destruction, increase the turbidity and the biological oxygen demand (BOD) of the waters, with a consequent decrease in the level of dissolved oxygen available for living organisms.

During a refinery's operational phase, there are several sources of oil contamination: operational spillage, pinhole leakage, accidental spillages and effluent release. Operational spillages may take place due to weak or improperly maintained links in the floating superstructure. Pinhole leakages are unnoticed leakages from pinholes in the pipelines that carry crude from the SBM to shore-based tanks or in product pipelines that transport petroleum products across the Gulf.
Modeling, assumes that a pipeline in the Gulf of Kachchh would have three leaking pinholes, from each of which oil would flow out at the rate of half a liter per second.

Accidental spillages are unforeseen spillages that occur, for example, during the transportation of petroleum, pipeline or tanker spills, coastal facility spills, tanker accidents and collisions, and so on. During the early 1990s, several fuel oil leaks in Gujarat's waters were recorded by the Coast Guard. In the last decade or so, as investments in the petroleum and petrochemicals sectors have soared, crude oil spillage accidents are increasingly being reported. However, only a fraction of actual spillage incidents received media coverage. The release of industrial and domestic wastewater from refinery complexes and townships into the Gulf is another major source of oil pollution. Gulf is a major breeding ground for marine organisms, their eggs and juveniles may suffer "considerable damage" when exposed continuously to hydrocarbons over long periods due to wastewater impact.

Oil Spills in the Gulf of Kachchh

Wildlife populations have been found to be most at risk from oil. The 1994 Gulf of Kachchh MNPS management plan identifies oil pollution as the "greatest potential threat to marine life and their habitat".Oil has a particularly pernicious effect on mangroves. In the third week of November, 1999, a large oil slick was detected near Narara Island off the Vadinar coast in Jamnagar. The spillage was traced to the Vadinar-Kandla pipeline of the Indian Oil Company (IOC) and is believed to have occurred when oil was being pumped from a tanker to the IOC's single buoy mooring (SBM). Walking around Narara, a press team reported seeing dead dolphins and sea turtles, besides long stretches of blackened mangrove. Hardly had the controversy died down when, seven days later, another spillage occurred in the same place: the Gulf of Kachchh near Vadinar port. Luckily, this time the 500 m-long and 300 m-wide oil slick spreading from the direction of Sikka, was spotted by workers on the crude tanker Maharaja Agrasen, which was waiting to berth at the IOC SBM.

In March 2004, heavy fog at night led to the collision between two vessels in the Gulf of Kachchh and approximately 678 tonnes of diesel, 4,530 litres of lube oil, 790 litres of gear oil and 1,022 litres of heavy oil were released into the waters of the Gulf.

Pirotan Island (a part of the National Park area, supposedly under the highest degree of environmental protection) were found to be caked with spilled oil and 3 ha of mangroves were found dead. The study also found layers of oil caking the surface of other "bets" (islands) in the National Park, and concluded: "In [the] absence of surveillance and monitoring, these minor spills were not recorded but...occurred undoubtedly in the past."

In 2001, a toxic gas leak of hydrocarbon from a petroleum refinery in Jamnagar is estimated to have caused about one million people in the city to experience headaches, breathlessness and a burning sensation in the eyes. In 2006, a fire in the Reliance refinery seriously injured a worker and caused a partial shutdown.Gulf of Kachchh still lacks a comprehensive oil spill contingency plan.

Chemicals

The abundant availability of limestone and common salt, materials required for the production of soda ash, has led to the establishment of giant soda ash plants along the coast at Mithapur, Sutrapada and Porbandar. Mithapur is located on the west coast in Gujarat's Dwarka sub-division. Its revenue areas mark the eastern boundaries of the Gulf of Kachchh MNPS62. The Tata Chemicals Limited (TCL) plant at Mithapur, spread over about 15,000 acres of land, is among the world's largest integrated salt works and inorganic chemicals complex. The main product groups are soda ash, chloro-caustic products, marine chemicals, salt and cement. According to the Department of Scientific and Industrial Research, about 10 cu m per tonne of effluent is generated during soda ash manufacturing. Going by these figures, the effluents discharged by TCL can be expected to have shot up nearly 30 times, from 3,30,000 cu m per year in the 1930s to 87,50,000 cu m per year at present.

A study carried out in 1993 stated that the Mithapur plant produces around 18 mn litres per day (mld) of highly alkaline process waste. The wastewater contains about 150 gm/l of suspended solids and 25 mg/l of ammoniacal nitrogen. This is released through marshy lands above the high tide line in the marine sanctuary area. Due to its high density, the milky white effluent does not mix well with sea water but instead spreads along intertidal areas or settles in heaps along the shore. The white colour of the effluent is due to high levels of suspended solids: calcium carbonate, calcium sulphate, magnesium hydroxide and silica.

The study found that the raw effluent was toxic. Even at 20 per cent concentration, fish did not survive in it for more than 15 minutes.
In the present decade, two devastating accidents have taken place within a three-year period. On 2 June 2001, a salt brine pipeline running through the marine national park, from a TCL factory at Samlasar to its Padli and Mithapur salt works, burst open, spilling thousands of tonnes of effluent into the PAs. In October 2003, there was yet another accident. This time, a TCL slurry pond burst, releasing 300,000 tonnes of calcium chloride into the PAs. Over 1,500 mangrove plants were killed.

Toxic Dumping

Cement

Although several cement companies operate in Jamnagar's Khambaliya taluka, in the immediate vicinity of PAs is the Digvijay Cement Co. (DCC), which belongs to the Aditya Birla Group. The cement plant at Sikka has a production capacity of 1.30 mn b. Until 1982, DCC was dredging materials from an area of 648 ha in the Gulf of Kachchh for its cement production. The area was leased out by the State government and included six coral reef islands, namely, Pirotan, Kalvan, Jindra, Dhani, Dera and Goose. These islands now fall under the National Park area. Sustained coral mining, at the rate of about 0.5 mn tpa by the company, caused major destruction of reefs. Satellite data showed a dramatic decline in coral reef cover in the region. Today, although the company cannot dredge within the PAs, it continues to extract raw materials from areas in the immediate vicinity, thus increasing the overall environmental burden in the Gulf of Kachchh. In the last 10 years, the loss of about 64 sq km of reef area has been reported within the National Park due to heavy sediment load.

Fertilizers

The Gujarat State Fertilizer Company (GSFC), located at Motikhavdi near Sikka in the vicinity of the protected zone, is the region's largest fertilizer company. It operates its own jetty at Sikka in the Gulf of Kachchh where phosphoric acid and liquid ammonia are offloaded from ships and pumped through pipelines over a 10 km distance to two plants, operated by contractors, for the production of the fertilizer diammonium phosphate. The 1994 MNPS management plan mentions that the transport of liquid ammonia and phosphoric acid through PAs is potentially a great hazard to marine life when pipeline leakages or bursts occur.

Salt works

Gujarat produces 70 per cent of the country's salt. For the last 60 years, salt works in Jamnagar have greatly contributed to the State's annual salt production. A massive salt works factory operated by TCL uses salt pans in the Okha Rann region and other areas of north Okhamandal, while smaller salt works are dispersed throughout Jamnagar's coasts,
inside or close to the PAs. In the vicinity of the MNPS, an area of 103.25 sq km of mangrove forests is leased out to 21 salt industries.

The bittern discharged and the negative water balance of the Gulf result in increased salinity of sea water and soil. Corals too are highly susceptible to change in sea water quality, especially salinity.
Bittern is toxic for mangroves. Between 1975 and 1982, the mangrove cover in the State decreased from 733.53 sq km to 177.31 sq km, a 76 per cent decline, while the area occupied by salt pans grew from 4.81 sq km to 49.13 sq km, a 921 per cent increase.

Thermal power stations

A 240-mw capacity, coal-based power station run by the Gujarat State Electricity Board operates in the vicinity of the PAs. The power station uses massive fly ash ponds extending over thousands of acres for fly ash disposal. At the Sikka port, the bulk transport of coal for the thermal power plant also poses a threat to marine life.

Significantly, several new thermal power stations are coming up in the region. Essar Power Holdings Limited plans to set up a 1,200-mw power plant in Jamnagar, based on coal imported from Indonesia and South Africa. The Reliance Group will develop a 500-mw coke-based power plant in addition to its existing captive power generation units at Jamnagar. Also coming up in the northern shores of the Gulf is Tata Power Company's 4000-mw ultra mega power project at Mundra.

Livelihood Issues of Traditional Fishing Communities

The settlement of the rights of stakeholders in the MNPS areas, including those of communities, has yet to be completed.

As far as the fishery is concerned, the situation is more ambiguous. The local perception among traditional fishers is that a plethora of legal regimes, without clear enforcement boundaries, compounds the existing problems of livelihood sustenance.
In most places, traditional fishers identified trawling as one of the key
reasons for the depletion of fish stocks and destruction of their gear. In the industrialized coastal belt, oil and chemical contamination, salt works and increasing port activity were stated as the reasons for declining catches.

In Sikka, near Jamnagar, along the southern Gulf of Kachchh, fishers say that oil and other chemical pollutants have depleted fish stocks.
Oil spills often cause the death of fish in large numbers, which, in turn, compromises the livelihood security of fishing communities. Correlating spills with fish mortality is, however, fraught with operational issues.

Multiple 'stakeholders' and legal regimes

In the Gulf of Kachchh MNPS, 87 per cent of the area falling under protection overlaps with the jurisdiction of the Gujarat Maritime Board, which is in charge of port development throughout the area.Apart from this, there are other overlapping activities, which include those of the Fisheries Department, the Department of Customs, the Light House Department and the Indian Navy as well as those of a growing number of hazardous and polluting industries. The island reef areas and creeks, which now fall within the MNPS, are also fishing grounds for a large number of fishers. Two islands within the MNPS area are inhabited: Bet Dwarka, which is an important temple and pilgrim site, and Ajad, which supports a small farming community. Many of the islands, such as Chusna, Pirotan, Ajad and Bet, are pir and dargah sites (traditional religious sites) hosting annual pilgrimages and fairs. The diversion of MNPS land for commercial use is also common practice. Approval was recently granted, for example, to the Indian Navy for the diversion of 0.41 ha of MNPS land for the construction of a Waterman Ship Training Centre to the Indian Oil Corporation for use of 24 ha of land of the Marine Sanctuary and 22.5 ha of the Marine National Park; and to the Gujarat State Fertilizer Company for the use of 12.47 ha of Marine Sanctuary land.Destructive commercial activities in the vicinity of PAs can lead to severe habitat loss and add to the environmental burden in the PA.

Why Collaboration of Department of Marine sciences, Bhavnagar University with NCSCM:

- Gujarat has longest sea coast.
- Plenty of issues on the coastal area and majority of them are critical issues.
- Our Department is the only Department in Gujarat State who run the course of M.Sc. Marine Sciences.We produce Master degree students in marine ecology. Thus we prepare skilled manpower to work on the environmental issues of the coast.
- We have well equipped laboratory with following Research Facilities available:

    1. pH Meter
    2. Salino Meter
    3. TDS Meter
    4. BOD Analyzer
    5. Turbidometer
    6. Spectrophotometer
    7. Centrifuge
    8. Digital Balance
    9. Grab Sampler
    10. Water Sampler

- We can work with the following three major divisions of the NCSCM

    1. Coastal Impact Assessment
    2. Conservation of Coastal and Marine Resources
    3. Knowledge, Governance and Policy

- Coastal Impact Assessment - In this division we can work on/ carry out research on;
    1. Coastal/ Marine Pollution (Monitoring, Analysis and Effect on Organisms)
    2. Coastal/ Marine Ecosystem (Survey, Assessment and Monitoring of Biodiversity).
    3. Coastal Environment Impact Assessment.
    4. Coastal Tourism (Monitoring and Effect)
- Conservation of Coastal and Marine Resources- In this division we can work on/ carry out research on;
    1. Coastal Living Resources (Monitoring and Survey)
    2. MPAs (Monitoring and Survey)
- Knowledge, Governance and Policy - For the capacity building we can carry out Training programmes like;
    1. Cultivation of Seaweeds, Prawn.
    2. Eco Tourism development and training to the villagers of coastal area for that.
    3. Training of Fisher Folk to work for conservation of coastal resources.

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Major Coastal Issues in Andaman and Nicobar Islands

The Andaman & Nicobar (A & N) group of Islands consists of 572 islands, islets and rocks lying in the South Eastern Part of the Bay of Bengal between latitudes 6° and 14° N and longitudes 92° and 94° E. The Andaman group consists of 324 islands of which 24 are inhabited while the Nicobar group includes 28 islands of which 12 are inhabited. The Andaman and Nicobar islands are facing problems such as population growth, forest degradation, habitat alteration, etc., and hence more attention is required for conservation and management aspects of the Island. Integrated Coastal Zone Management (ICZM) is an effective tool for sustainable management of the coast.

In the Andaman Group, only 20 are the major inhabited islands:- such as Aves, Baratang, Cinque, East, Havelock, Interview, John Lawrence, Little Andaman, Long, Middle Andaman, Neil, North, North Andaman, North Passage, Peel, Rutland, Smith & Ross, South Andaman (part), Stewart and Strait Islands.
Major coastal issues observed in Andaman Islands are listed in Table 1. With the exception of South Andaman, the coastal areas of all other islands are not developed and hence at present in Andaman Islands the issues are related to developmental potential. The fisheries and tourism sectors have enough potential to grow in Andaman Islands. Based on a detailed study, the following developmental activities were proposed i.e. tourism, mariculture, water storage areas and check dam sites, windmill sites and sites for port/ jetty development.

Andaman has a diverse coastal environment with a variety of ecosystems and an extremely rich biodiversity and productivity. The number of visitors to this island is quite high and their interest is increasingly oriented towards natural destinations. One of the main sources of income in Andaman is tourism and in addition they have good potential for ecotourism.

Out of the twenty islands, six are most populated i.e., South Andaman, Middle Andaman, North Andaman, Little Andaman, Baratang and Havelock. Environmental degradation has been observed due to the increasing population pressure resulting in severe depletion of natural resources. It is therefore important to augment the resource base and promote employment opportunities in these islands. There is also a need to ensure that tourism activities are not concentrated in a few islands, as this would accelerate degradation of sensitive ecosystems. The average fish production of 26,624 tonnes per year forms about 11.5% of the estimated fishery potential of Andaman and Nicobar waters. This indicates that 89% of the fishery resources remain un-exploited every year.

Thus, there is good scope for generating revenue and employment in the islands from marine capture fisheries. Mariculture has also got good potential in Andaman and the potential organisms include Lobsters, Crabs, Prawns, Fishes, Pearl Oyster, Turbo, Tridacna, Trochus and Sea grasses. Therefore mariculture activity has been proposed in some of the suitable islands to increase revenue generation.

Fig. 1: Map of the Andaman and Nicobar Islands

In order to promote tourism and mariculture in these islands, sufficient infrastructure facilities are required. Two of the major constraints to development in Andaman are the availability of water and energy. Water storage structures and check dams were proposed in order to augment the water resources of these islands. At present diesel is being utilised for energy generation. This could lead to air pollution and hence wind mills, which are a source of clean energy have been suggested to help the islanders meet their energy requirements. Accessibility is a very important issue as far as tourism goes. In view of this, the Ministry of Shipping had recommended certain points for the development of port/ jetties in Andaman Islands to improve harbour facilities. However only certain sites are recommended by us based on the proposed developmental activities and existing port/ jetty facilities. Table 1: Common Coastal Issues identified in Andaman and Nicobar Islands ('+' Increase in area; 'x' Absent; '-' Decrease in area and 'NC' No change observed) In our earlier recommendations we had suggested to reduce the limit of No Development Zone (NDZ) from 200 m to 50 m. But the post tsunami situation suggests that 50m will be too close to the beach and the developed infrastructure facilities will be vulnerable to any natural hazard such as Cyclonic Storms, Tidal Waves and even Spring tide flooding. Hence it is now recommended that NDZ limit should be maintained at 200 m and wherever it is possible the infrastructure facilities should be developed at 20 m elevation level. However this can be relaxed on a case to case basis depending on the location, infrastructure availability and geomorphology of the region.

Coastal Issues

Basic amenities such as electricity, education and medical facilities are not available in all the islands and those with major developmental activities are intervened by human interference. The major coastal issues observed in Andaman Islands are a) Loss of Coral Reefs, b) Mangrove Deforestation, c) Loss of Sandy Beaches and d) Loss of Forest (Table 1).

Islands	Coastal Issues				
	Settlements	Coral reef	Mangrove	Sandy Beach	Forests
Aves	x	+	x	+	+
Baratang	+	+	+	-	-
Cinque	x	-	x	-	-
East	-	+	-	-	+
Havelock	+	-	-	-	-
Interview	+	+	-	+	-
John Lawrence	x	+	-	-	+
Little Andaman	+	+	-	-	-
Long	+	-	-	+	-
Middle Andaman	+	-	+	+	-
Neil	+	-	+	+	-
North	x	x	x	+	-
North Andaman	+	-	-	+	-
North Passage	+	+	+	-	+
Peel	x	+	-	+	NC
Rutland	+	-	-	-	-
Smith and Ross	+	-	-	-	-
South Andaman	+	+	-	-	-
Stewart	x	+	-	-	-
Strait	+	+	-	+	-

Loss of Coral reef

Coral reef area cover were identified and mapped using SPOT 1988, IRS 1B LISS II 1993 and IRS LISS III 2003 satellite imageries and were estimated using ArcGIS software. Coral reefs are seen in almost all the islands except North Island. Out of the 19 islands, 10 islands have experienced loss of coral reef area (Table 8.1). The islands where the coral reef area has decreased are Cinque, Havelock, Long, Middle Andaman, Neil, North Andaman, Rutland and Smith & Ross islands. The most serious threat to the reefs is by tourism, sedimentation, human-induced siltation, agricultural run off, destructive methods used for fishing and storm damage.

Mangrove degradation

Mangrove extent was identified and mapped using SPOT 1988, IRS 1B LISS II 1992 and IRS LISS III 2003 satellite imageries and was estimated using ArcGIS software. Mangroves are found in seventeen islands and mangrove degradation was noted in thirteen islands, which are East, Interview, Havelock, John Lawrence, Little Andaman, Long, North Andaman, Peel, Rutland, Smith & Ross, South Andaman, Stewart and Strait islands. Some of the threats to mangroves are by the rural people in coastal areas who extensively use mangroves as fuel wood, encroachments in mangroves in some area, tourism, sand mining and quarrying along the coastal belt and frequent cyclonic storms. Degraded mangroves are observed in Sipighat, Junglighat and Govindapuram (road has been constructed across the mangrove patch which arrests the to and fro motion of water, thereby resulting in degradation on the north-eastern side) of South Andaman and around the jetty of Havelock Island (degradation in the form of development of restaurants, settlements and plantations).

Loss of Sandy Beaches

The occurrence of sand in Islands is confined to a thin strip all along the coastal region. Majority of the islands in Andaman group have rocky coast. Since all the major developmental activities need sand as the raw material for construction, the demand for sand is high. The economic value of the sand is also high. Hence to utilize this resource in an efficient manner, site-specific management plans are needed. Erosion and accretion areas were identified and mapped using SPOT 1988, IRS 1B LISS II 1993 and IRS LISS III 2003 satellite imageries and were

estimated using ArcGIS software. Out of the 20 islands erosion or loss of sandy beaches were seen in Baratang, Cinque, East, Havelock, John Lawrence, Little Andaman, North Passage, Rutland, South Andaman (part), Smith & Ross and Stewart. Sand mining was witnessed in Chidiatapu of South Andaman which also contributes to loss of sandy beach. Since these places are turtle breeding sites as well as favourable places for promoting ecotourism, any proposed sand mining activity in these regions should be controlled.

Loss of forests

Changes in forest areas were identified and mapped using SPOT 1988, IRS 1B LISS II 1992 and IRS LISS III 2003 satellite imageries and were estimated using ArcGIS software. Out of the 20 islands loss of forest were observed in fifteen islands. The loss in forest cover represents the degraded condition of this ecosystem where dense forest patches have become sparse forests as witnessed in Peel Island where forest density has decreased.

Some of the important issues that needs to be addressed in the context of coastal management in the Andaman and Nicobar Islands include:

- Natural Resources Management
- Agriculture
- Tourism
- Fisheries
- Pollution
- Sea Level Rise
- Infrastructure Development

The existing State Coastal Zone Management Authority could be strengthened by including a few more stakeholders and could be used for ICZM Plan development and its further implementation. Strategies and recommendations must be properly formulated based on the resource exploitation, developmental potentials and the existing information available.

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T.N. Prakash

The Lakshadweep islands have long conjured up images of ‘paradise’, but their amazing lagoons and coral reefs have started showing signs of increasing stress. As the island communities strive to raise living standards for growing populations, there is always a tendency to sacrifice the fragile ecosystems, which are among their most valuable assets. There is always a chance to overexploit their natural resources and degrade the environment. Another alarming scenario is the rising sea levels and climate change, predicted to result primarily from global greenhouse gas emissions. This could damage coastal areas and even submerge the low-lying islands. It would profoundly affect island economies, with a negative impact on fisheries, tourism, coral reefs and freshwater supplies. Islands are also important contributors to global biodiversity; their lagoons and coral reefs are home to many species not found elsewhere, but these habitats are suffering considerable damage and, in the case of native endangered species, potentially irreversible losses. Ensuring sustainable development is the immediate necessity to prevent the possibility of the islands plunging into an environmental disaster. This will improve the islands’ ability to manage their resources including fishery resources.

The islands face a number of issues. The following are the most important ones requiring immediate management intervention:

- Coastal erosion and shore protection
- Fresh water management
- Conservation of coral reefs/mangroves
- Fishery resource exploitation and catch enhancement
- Sewage and solid waste treatment
- Tourism
- Infrastructure development
- Environmental education for people

Other important issues to be addressed are:

- Regulatory controls
- Environmental quality enhancement
- Alternate employment generation

5.1 Coastal Erosion and Shore protection

Coastal erosion is a serious problem faced by the islands every year. With a miniscule landmass of 32 sq. km and an altitude of 2-6 m above MSL, erosion of every square inch is a serious loss. It has also been reported that global climate change due to greenhouse effect is predicted to cause sea level rise as much as one meter in the next century and would result in flooding, land erosion, and or even submergence of islands. The Lakshadweep islands have witnessed an unprecedented flooding and erosion of some of the islands during May 2004 due to cyclonic storm (CESS, 2004). These islands have an added advantage over the other low lying tropical islands since they have coral reef edge that can grow and also would act as a living sea defenses. The islands are coral atolls defended from the sea by live coral and if sea level rise doesn't occur at an excessive rate; coral growth may in principle be able to keep pace with it. The rate of sea level rise, which would put the Reef below water level, may not be fatal to it. The coral can grow at depths of 10 m or more below the sea, a figure far in excess of the most pessimistic sea level rise. This can only be conjectured but not the definite one. In many islands during the 7th five-year plan period there was a spurt of activities in the islands' coastal zone like construction of jetties, harbor and port, widening of entrance channel, etc. During these developmental activities part of the reef was removed. Replacing the removed reef through Artificial Reef is one of the management options to avoid the flooding and erosion of coast. The long-term shoreline change for all the inhabited islands is shown in Table-1.

Table - 1: Long-term shoreline changes in the island (Source: Prakash et. al., 2005).

Island (Km)	Perimeter	Length (percentage) of shoreline(Km) under		
		Erosion	Accretion	No Change
Kavaratti	11.45	4.15 (36)	7.12 (61)	0.18 (1.5)
Agatti	16.14	9.01(56)	6.34 (39)	0.79 (4.8)
Amini	6.67	2.45(36)	3.85(57)	0.37(5.3)
Androth	10.59	4.47(42)	0.92(8.6)	5.2(49)
Bangaram	3.51	2.17(61)	1.34(38)	-
Kalpeni	11.85	2.53 (21)	2.01 (17)	7.31 (61)
Minicoy	23.07	9.98 (43)	3.58 (15)	9.51 (41)
Kiltan	7.81	3.64(46)	3.18 (40)	0.99 (12)
Chetlat	5.82	2.14(36)	3.2(55)	0.48(8)
Kadmat	18.37	5.55(30)	9.82(53)	3.01(16)
Bitra	1.3	0.11 (7.86)	1.14 (81.42)	0.15 (10.71)
Total	116.58 km	46.2 km		

The data indicates that about 40-60% of the coastline of Bangaram, Agatti, Kiltan, Minicoy and Androth islands and 30 to 40% of Kavaratti, Amini, Chetlet and Kadamat are affected by erosion. The analysis of implementation schemes for coastal protection is given in Table-2.

Present Status	Management Option	Feasibility
Many areas have been protected by Tetrapods and low-cost shore protection structures	Continue with low-cost shore protection/ maintenance work	Many adverse impacts – loss of beach, affects the Tourism industry, shore based fishery, etc.,
	Retreat or moving to safer location	Retreat is not possible since the land area is less. Partial relocation can be worked out.
	Beach nourishment	Studies on the design beach, dredged sand can be used, sand resource in the lagoon bed to be identified.
Low cost shore protection structure caused loss of frontal beaches and damage to tourism/fishery industry	Groins	Careful design is needed, lee-side erosion, helps in beach formation on one side or in between two groins.
	Artificial Reef	Prioritize areas of reef construction; develop proper reef design, which can induce the formation of beach. It helps to regenerate beach and offers recreational facilities for tourists

Coastal monitoring programmes are an important component of ICZM. They provide necessary information on how the coastal systems are changing due to the natural and human-induced and thus provide the foundation on which decisions can be based. As part of the coastal erosion studies in Lakshadweep islands during 1990-2005, CESS has established regular monitoring stations for monitoring of beaches in all the inhabited islands. Based on the study base line information is available in the islands. What is required now is the periodic monitoring from the same established stations to provide information on the long-term beach changes in the islands.

5.2 Fresh Water Management

Potable water is the most critical natural resource that requires immediate management intervention. Based on the present requirement, Kavaratti, Minicoy, Agatti and Amini islands are classified as deficit. Chetlet and Kalpeni may become deficit between 2005 and 2010 AD.

In view of the above scenario, good landuse practices, water recycling, creation of awareness among the people and rainwater harvesting has to be carried out to sustain the water resources in the islands. The Administration has already started installing some of the schemes in the islands. Desalination of water through reverse osmosis or OTEC is another viable options for augmentation of water supply to the island.

5.3 Sewage and Waste Water Management

The sewage and solid waste disposal is a major problem faced by the islands. The increasing population pressure and related development activities have put enormous pressure on the island ecosystem. Though these developments give room for concern, some of the activities in consonance with the delicate ecological balance sustain the islands. So any imbalance is likely to harm the Islands and the Islanders. The island communities create considerable amounts of sewage waste (50,000 to 1.2 lakhs litre/day), which is often left into septic tanks, or cesspools that leach organic matter and pathogenic bacteria into shallow fresh water lens. The inhabitants of the islands depend mainly on the groundwater, which floats as thin lens on seawater under equibilibrium conditions. Because of dense population, highly porous coral soil, shallow nature of aquifer and the proximity to leach pit/septic tanks to the dug wells, the potable water is exposed to bacterial contamination. This causes great risks to human health. The nutrient rich sewage will lead to high rate of eutrofication in lagoon waters resulting in excessive weed growth and depletion in the dissolved oxygen content, which is deleterious to the healthy growth of corals. Further the pathogenic bacteria often associated with sewage will render the coastal waters unfit for contact water usages. According to tests conducted during February 1991 in Kavaratti and Minicoy a number of drinking water wells contain excessive nitrate concentration originating from septic tanks, other human wastes and fertilizers used in gardens. In almost all drinking water sources like hand pumps, wells, ponds, bacterial contamination is noticed. 98% of 126 samples showed a positive coliform count. With quantum of sewage generation doubling by the year 2025 and with no sewage disposal system the potable water lens would be so severely contaminated that it will no longer be potable even after boiling and chorine treatment. The Island Administration is aware of the danger and is making concerted developmental strategy to mitigate the problem.

The first step in wastewater management is to control the sources of waste and the second is to treat the waste. In the island, the linking of cluster settlement is the best option, which can have a centralized sewage collection and a preliminary treatment through aerobic oxidation principle. The sewage generated from houses should be taken to a common collection tank. The wastewater from the collection tank is pumped at the required rate to the diffused aeration tank where the biological media is provided. This ensures the aerobic microbial growth utilizing the oxygen supplied by the diffused aeration system, which reduces the organic matter. The diffused aeration system comprises of fine bubble membrane diffusers, which are installed at the bottom of aeration tank. Air from the blower at the desired rate and required pressure will be diffused through the diffusers. From the aeration tank the water flows to the post sedimentation tank where the biomass is separated by sedimentation. This will remove suspended solids including organic matter from the waste stream by digestion or oxidation. The sewage coming from the oxidation tank contains very small amount of solids in relation to the huge quantity of water (99%). The remaining solid matters (1%) become sludge. The residue sludge can be dried, thickened and can be used as soil fertilizer for Agriculture purpose. The liquid reminder, the effluent can be discharged after chlorination/disinfection into the Sea or can be used for Agricultural Farming.

A pilot Sewage Treatment Plant (STP) has been worked out for Kavaratti Island for a plant capacity of 1-lakh liters in collaboration with MoEF-DST with partial support from UNEP and CESS. The details are given below:

Capacity of the plant : 1-lakh liters
Space required for the plant : 120 sq.m (~ 3 cents of land)
Number of house that can be linked : 200 houses
Total number of persons benefited @ 5-persons/ house : 1000
Budget:
Cost of plant including erection : 40 lakhs

The treatment water* will be of class-II standard of water quality suitable for irrigation and contact water use (Table-3).

Table - 3: Quality of Treated water*

Parameters	Inlet Sewage Water	Treated Water	Pollution Control Standards
PH	6 – 8	6.5 - 8	5.5 - 9
SS	250	15	73
BOD	300	15	100
COD	500	< 200	250
Oil & Grease	30	5	10

A similar scheme can be worked out for other inhabited islands.
Another important environmental issue that needs to be addressed is the disposal of solid non-biodegradable waste. Lakshadweep islands have no organized waste disposal system. With the result the waste like plastic, polythene, glass materials, etc., keeps on piling on the islands, spill over into lagoon cluttering the lagoon causing serious damages to the corals and fishes. In 1996, a system of non-biodegradable waste disposal system has been introduced at Kavaratti. Through this scheme the waste was collected and deposited at specially created garbage depository and shipped to mainland for re-processing/land filling etc. For a regular waste disposal, garbage bins have to be installed in all the other inhabited islands. Bins have to empty once in a week. The work can be assigned to an NGO for collection and shipping to mainland from time to time. For disposal of bio-waste a system of composting processing can be implemented. The most appropriate mode of disposal appears to convert the biodegradable waste into bio-fertilizer by open pit Aerobic composting process.

5.4 Conservation of Lagoons and Coral Reefs

In Lakshadweep, the lagoons and corals are the two unique elements of nature of which lagoons maintain exceptionally high levels of biological productivity and play important ecological roles by exporting nutrients and providing habitat and breeding ground for young species. The most likely sources of pollution to the lagoons are from the land-based activities. Dredge and fill activities related to the port development also affects the lagoon water circulation. Therefore excavation of lagoons bottom to create navigation channels and, harbour must be controlled. In the management option a buffer strips above the HTL has been suggested to control sewage and storm drainage effluents from the island, safeguards against runoff soils from the island, etc. If developments on the lagoon shore are not planned properly it creates a variety of short and long-term economic losses.

The scientific studies world over shows that up to 70% of the world coral reefs may be destroyed in the next 20-40 years, if destruction continues at its present rate. Current activities undertaken by different institutions on coral reefs are sporadic and isolated, mainly because of the lack of physical facilities for reef research at any one region of the island. Another approach that has proved effective for coral reefs surrounding the surrounding small islands is the development of a marine reserve and sanctuary model. This model basically encourages local communities to be responsible for their fishery and coral reef resources. The reserve model provides limited protection for coral reef and fishery surrounding the entire island but strict protection from all extraction or damaging activities in the area where the coral reef coverage exceeds 20% (White, 1988). This reserve and sanctuary approach can provide real benefits to local fishing communities in the island through increased or stable fish yields from coral reefs that are maintained and protected. The resource management must be rooted through the local island communities to conserve their own marine resources. In summary the effective coastal resource management in the islands is more than a problem of environmental consideration or law enforcement. Community based approaches that mobilize those people who use the resources daily are required to participate in the programme. Strict regulatory mechanism alone will not give desired results. Combining community, environmental surveys and legal approaches in a manner appropriate for a particular island offers some possibility of success. The churning motion of the propellers in the shallow water is one of the causes for resuspension of sediments. A fraction of the coral mortality in the island is ascribed to the smothering effect of the resuspended sediment. Recommended measure is the exploration of the utilization of fan-driven crafts - of the type 'Swampbuggy' - for shallow water traffic.

5.5 Infrastructure Development and Associated Issues

For all round development of the island there is need to improve the infrastructure facilities around the island. At present most of the developmental activities are restricted to the lagoon coast. The important activities that needs further improvement has been discussed below:

a) Port and Harbour development

Port is a major sector in the Lakshadweep Administration. The facilities provided in the port and harbours are not usually thought of as infrastructure, but rather as clients of infrastructure. Ports usually serve one or more type of activities: (a) Shipping industry which requires channels, port facilities, boat yards and extensive land areas for loading and unloading of goods (b) Passenger vessels for Embarkation/disembarkation (c) Fisheries development, which requires breakwaters, channels, ports, processing plants, and other facilities for fishing fleet and (d) other operations, which requires special port facilities and support services.

The port facilities are mainly used for ferrying between mainland and the islands and in between islands of Lakshadweep. At present two all weather ships viz., MV Bharath Seema and MV Tippu Sultan and 3 fair-weather ships MV Deepusetu, MV Aminidevi and MV Mincoy are operating between mainland and islands. Two inter island ferries of a capacity 100 each are operating in between islands. Besides there are 4 number of 300 tones capacity cargo barges/vessels, which carry bulk of the cargo from mainland to islands and vice-versa. As shallow lagoons and coral reefs surround the islands, the bigger vessels from the main land have to unload the goods on high seas from ship to boat with high risks. The risk is increased many folds during the monsoon. To overcome the problem long term plans to construct breakwater on eastern side is proposed. The construction of second stage breakwater at Androth is in progress. Similarly at Kalpeni the work has started. The periodic dredging and widening of channel on the lagoon bed from entrance to Jetty in every island is required. There is no escape from undertaking these operations with due precaution. The dredged material after periodical dredging can be used for beach nourishment on the lagoon coast.

b) Tourism

The Lakshadweep Administration has declared tourism as an industry. A minor environmental impact is unavoidable consequence of the growth of tourism in the islands. The negative impacts can be minimized if priority is given to the identification and evaluation of resources and potential impacts and a planning and control system is established. One serious impact from tourism development worldwide is that of a decline in local water quality mostly from the sewage. This will adversely affect the biota, destroying valuable fishing and coral habitats. All these years the Administration has taken tourism in a controlled way. Now many schemes are in pipeline, which needs utmost care (Table - 4). A successful tourism strategy is to seek maximize the profits while preserving the natural environment. The existing infrastructure in the government sector has 20 huts and 17-beach accommodation in different islands. In private sector there is an Island Resort at Bangaram with 60 beds and at Agatti with 20 beds. Annually the average tourist arrivals to the island are 3000 domestic and 1500 foreigners. There is every scope for further improvement of tourism in the Lakshadweep islands.

The most outstanding strength of the island is their marine wealth including open sea, lagoon, coral reefs, beach and island. These attraction and possibilities of sea based activities need to be encouraged. The survey conducted as part of the study (Annexure-III) indicated that the local residents are extremely helpful and suggested more infrastructure facilities to be created with least resource exploitation from the island for tourists. There are many constraints at present like the low carrying capacity, poor transport infrastructure, an absence of vision plan for islands' own natural resources, etc., These constraints need to be addressed for the development of Lakshadweep islands as one of the top destination for beach tourism and water sports activities.

Based on the ICZMP approach we have identified locations/areas suitable for tourism and for creating other infrastructure facilities in all the inhabited islands including Bangaram and Tinnakara. The approach involves the selective approach of not recommending the large-scale land based projects since the sea space is more than the land space in the islands. In some of the islands the land-based projects are suggested mainly to improve the infrastructure facilities. Also many of the recommendations considered are part of the perspective developmental plan fall within the ambit of improving the existing situation with appropriate with policy inputs and corrective measures.

Table – 4: Analysis of implementation schemes for Tourism

Present Status	Management option	Feasibility
Tourism is a major revenue earner for the islands	Continue with better infrastructure facilities	Positive impact
	Opening the uninhibited islands for increased tourism	It is good for island economy, generate employment, Negative environmental impact like more sewage, waste and resource consumption
Depletion of potable water and use of limited resources in the islands	Rain water harvesting & Sewage Treatment plant	It is positive. The island community will not be depriving of the limited resources in the island.
Increase the water related activities in the lagoon	More water sports and scuba diving centre in the islands	Develop in uninhabited islands like Tinnakara, Cheriyam and in other islands

The tourism in the islands could be developed as a priority through grouping by considering the existing infrastructure facilities and closeness between the islands. Four groups were recognized viz., Kadamat, Amini, Chetlet, Kiltan and Bitra (Group I), Kavaratti, Agatti, Bangaram and Tinnakara (Group II), Androth, Kalpeni, Thilakam, Cheriyam (Group III) and Minicoy and Viringili (Group-IV). The suitable land area available outside the HTL were identified in the island and is shown in the ICZMP map. Further care is required for the development-based carrying capacity of island, which refers to the capacity of an ecosystem to sustain specified resource uses.

c) Fisheries

Though the commercial fishing activity in the islands is by and large centered on Tuna but the other species are totally neglected. The fishermen used to migrate to uninhabited islands since they are known as the best tuna fishing grounds in Lakshadweep. More than 25% of the present landing is accounted from these uninhabited islands. Pole and line fishing method, which was indigenously developed some decades back, is still employed for Tuna fishing and practically there is no involvement of other fishing techniques in the exploitation of Tuna though very efficient techniques are now available. Shortage of live bait is deeply felt among Lakshadweep fishermen and this may be the major constraint in the intensification of tuna fishing. Presently the tuna canning capacity in the island is 3 lakhs cans of 200 grams per annum at a total value of Rs.150 lakhs. Neighboring country Maldives produces approximate 2 lakhs cans per day. Production of Tuna can as also Masmin is linked to availability of Tuna. With Fish tapping 25% of harvest against the present 10%, it would be realistic and sustainable with necessary safeguards to aim for production of 10 lakhs can to 20 lakhs can per annum yielding Rs.5 crore to 10 crore at current rates. Masmin production can also be trebled and can add to economic yield. Shark value added product is untapped and this can be added. Mariculture has not been attempted in the islands. The vast lagoons offer a good scope for mariculture of a variety of species including pearl oyster. Though the Administration has made a beginning on the culture of ornamental fishes but still there is a scope for further improvement.

Non-availability of proper storage facility and no demand in the internal market are the main reasons for their non-exploitation. The fishes offer a very good demand globally and there is acute scarcity faced by the agencies such as Matsyafed, Integrated Fisheries Project situated in Kochi and the number of super markets in Kerala, who are involved in fish marketing in Kerala. The possibility of marketing of these fishes through these channels can be explored further.

Any developmental programme for improving the economy of Lakshadweep and to provide employment to the increasing population has to be mainly oriented towards the fishing industry. In this context, conceptualization and implementation of the viable projects targeting towards tapping the unexploited fishery resources including both tuna and other fishery resources deserve top priority.

Concurrently, the setting up of the essentially required infrastructure for proper storage, preservation and transportation commensurate with high production is also essential for the futurological development of fisheries sector of Lakshadweep. Implementation schemes/management options are given in Table-5.

5.6 Environmental education for people

The developmental projects proposed in the ICZM plan requires environment assessment processes for the possible impacts they have on the coastal resources. However some recommended policies were suggested as part of the CZM plan to reduce any negative impacts. The high density of dwelling units in certain islands very close to the coast has affected the environmental quality. The limited land availability and population pressure has put

Table – 5: Implementation schemes/management options for fishery sector

Present Status	Management option	Feasibility
Fishery is the major occupation	Continue as such	Will not bring any substantial improvement in economy
	Improve and provide more infra structural facility in fisheries sector	Improvement in fisheries sector is possible and will generate lot of employment.
Diversification of Fishery sector	Mariculture and value added products from fish	Development of value added fish products including the development of pearl oyster and ornamental fishery.

enormous pressure on the island resource. The population of approximately 60,000 during 1997 at the beginning of 9th five-year plan is projected to double at the present day growth by the year 2025. Even if the rate of growth declines, by all indications, one lakh population mark shall be crossed by the year 2025 (Ref. EIA 9th plan period-DST, 2002). There is an urgent need to educate the people to have small family considering the limited resource they possess.

5.7 Additional Employment Generation

The additional employment generation in the island can be taken up successfully by considering the local resources and environmental aspects. Due to high literacy rate in the island the general preference by the youths is for the salaried jobs under government. The youths can be encouraged to set up their own enterprises utilizing the resources of the island in a limited way. Some of the activities, which have potential to generate high growth of employment, are fisheries, tourism, agriculture, horticulture, drinking water and sanitation including the infrastructure developments. These activities would have to be taken on priority basis in order to achieve the full employment generation in the island. Substantial generation of employment is possible in the fisheries sectors and the detail recommendations are given Annexure-I. Tourism is the other important sector where substantial income to the local people is possible by opening more tourism development in Lakshadweep.