सत्यमेव जयते

जहाँ है हरियाली |
वहाँ है खुशहाली ||

SOCIETY OF INTEGRATED COASTAL MANAGEMENT
SICOM

ANNA UNIVERSITY
PROGRESS THROUGH KNOWLEDGE

NCSCM

NATIONAL CENTRE FOR
SUSTAINABLE COASTAL MANAGEMENT
Ministry of Environment and Forests, Government of India




2013 – 2014

ANNUAL REPORT

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- Prof. M. Sekar, Dean, College of Engineering Guindy, Anna University, Chennai [Expert Member]
- Director, NCSCM [Ex-Officio Member-Secretary]

Preface

Complex and diverse types of natural processes that occur on the coastal zone bring in physical, chemical, and biological changes to the fragile coastlines. Human activities in the coastal zone add yet another dimension affecting changes to our coastlines. Considering the growing need for sustainability of the coast, the Ministry of Environment and Forests (MoEF), Government of India with the support of Anna University, Chennai established the National Centre for Sustainable Coastal Zone Management (NCSCM) in February 2011 to be a world class institution for sustainable coastal management with a strong research and knowledge base. NCSCM, MoEF identified research institutes in each of the Coastal State/ UTs under the "Anna University Declaration" to enable representative coastal universities and institutions function in a Consortium mode.

NCSCM has an advanced and multi-disciplinary research agenda, spanning physical, chemical, biological, social and economic disciplines through field surveys and extensive remote sensing and GIS applications. NCSCM has for the first time mapped the entire coastline of India to assess the shoreline change and to enhance the country's preparedness to coastal hazards. The MoEF has evolved the concept of preparing the Integrated Coastal Zone Management (ICZM) Plan for the Country's coastline for which NCSCM is providing the Guidelines to the Coastal States/ UTs. NCSCM is also undertaking the delineation of Coastal Sediment Cells and mapping of Ecologically Sensitive Areas, with emphasis on traditional knowledge.

I wish to thank the Hon'ble Union Minister of State for Environment and Forests Smt. Jayanthi Natarajan and the High Power Research Steering Committee for setting high standards of research goals for NCSCM. I would like to thank Dr. V. Rajagopalan, I.A.S, Secretary E&F for the continued support and guidance on the research programmes. The support provided by the Vice Chancellor, Anna University & Chairman, Governing Council, the Registrar and all the members of the Governing Council is greatly acknowledged. The immense support of Shri Vivek Wadekar, National Project Director and Shri Tapas Paul, Task Team Leader, World Bank are gratefully acknowledged. The activities and periodic updates are available at the NCSCM website www.ncscm.org

Prof. R. Ramesh

An Introduction

NCSCM

National Centre for Sustainable Coastal Management (NCSCM) is established as an autonomous institution, with an aim to become a world-class institution for coastal and marine area management with adequate human resources, facilities and assured long-term funding. It would promote integrated and sustainable management of coastal and marine areas in India and advice the Union and State Governments and other associated stakeholder(s) on policy, and scientific matters related to Integrated Coastal Zone Management (ICZM). The Centre is established within the Anna University Campus, Chennai. Fourteen institutions have formed a consortium with NCSCM, with Anna University Chennai as the Hub. The Centre will become a centre for excellence within India on coastal research, management.

The outputs from research at NCSCM would aid in the better protection, conservation, rehabilitation, management and policy design of the coast. NCSCM would guide and coordinate the implementation of ICZM approaches leading to enhanced conservation of coastal resources and sustainable development along the coast of India through applied and futuristic research. The centre would develop a central repository of information and knowledge on ICZM practices in India and elsewhere. The centre will partner with national and similar international institutes to share knowledge in protection, conservation and management of the coastal areas. Further, NCSCM would promote technically sound and practical management approaches to ICZM.

Goals

Objectives:

A. Strive to become and remain a World-class knowledge institution pertaining to understanding coastal zones and coastal processes, and pertaining to integrated planning and management of coastal and marine areas

B. Promote integrated and sustainable management of the coastal and marine areas in India for the benefit and wellbeing of the traditional coastal and island communities

C. Advice the Union and State Governments and other associated stakeholder(s) on policy, and scientific matters related to ICZM

Vision

"Promote sustainable coasts through increased partnerships, conservation practices, scientific research and knowledge management for the benefit and wellbeing of current and future generations"

Mission & Role

Support integrated management of coastal and marine environment for livelihood security, sustainable development and hazard risk management by enhancing:

- Knowledge
- Research and Advisory Support
- Partnerships and network
- Coastal Community interface

NCSCM has the following primary goals:

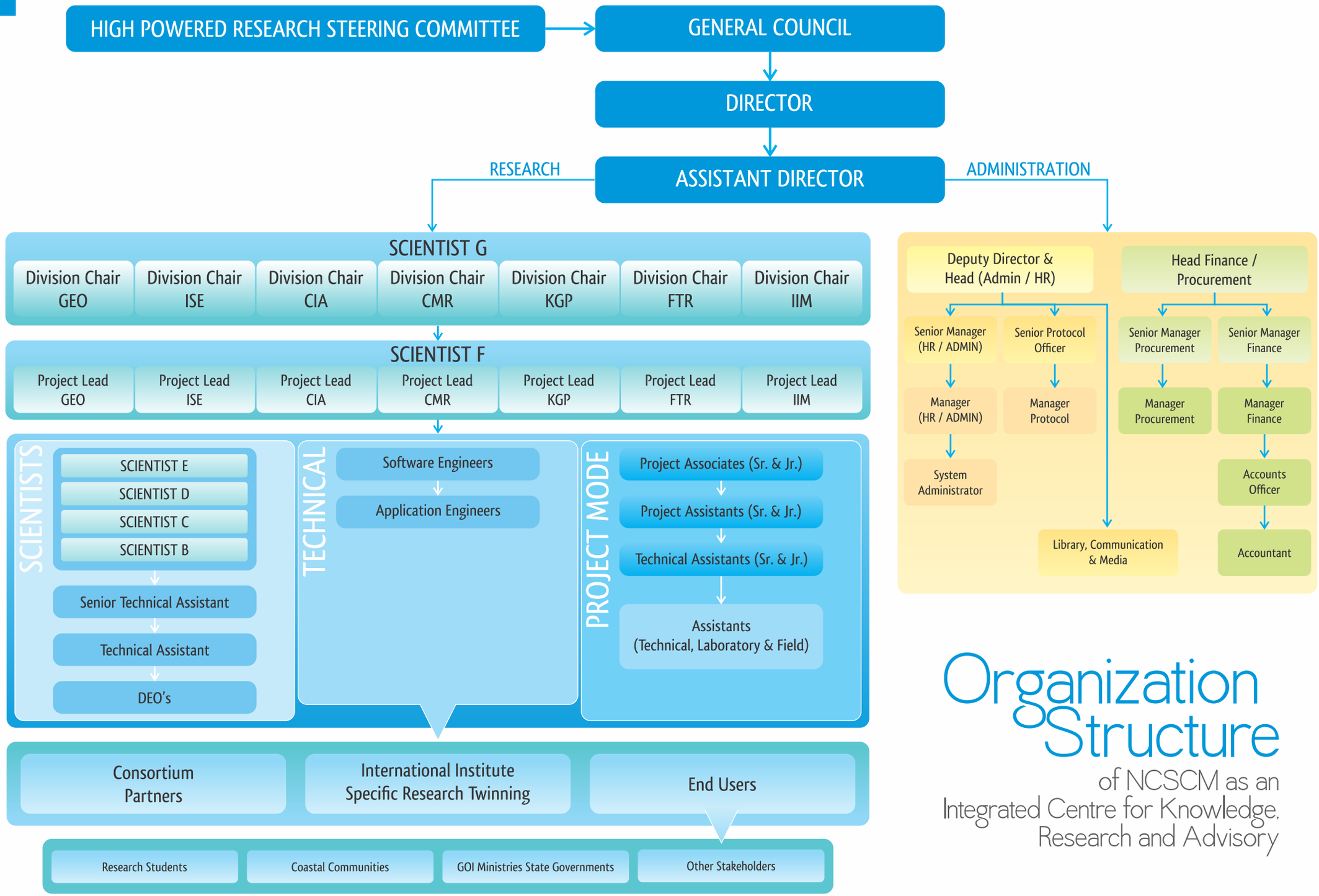
- To become a world class institution for sustainable coastal management with a strong research and knowledge base
- Create a Consortium of Institutions in India to strengthen capacity in multi-disciplinary research related to coastal management

Organization Structure

Administration of the institute rests with the Director, who receives support from both research divisions and administration. The High Powered Research Steering Committee (HPSC), the Governing Council (GC) and the Managing Committee (MC) review and monitor the research programmes and facilitate to identify new research thrust areas for the Institute.

To accomplish the mandate, the research activities are organized under seven divisions namely

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



Organization Structure

of NCSCM as an Integrated Centre for Knowledge, Research and Advisory

Research Divisions of NCSCM

The Geospatial Sciences Division (GEO)

The objectives of the GEO are to provide scientifically-based decision support system to a wide variety of users, to promote environmentally sound use of coastal resources by employing the state of-the-art technology in geographic information systems (GIS) modeling, and field surveys. The major groups under the GEO are: (i) the Land Survey, (ii) the Hydrographic Survey, (iii) the Cartography , (iv) the Digital Photogrammetry, Digital Image Processing and ALTM Laboratory, and (v) the GIS Work Centre and Data Warehousing.

Integrated Social Sciences and Economics Division (ISE)

The ISE would focus on coastal communities and their livelihoods. In particular, the ISE would focus on community based approach to coastal vulnerability and coastal management with collaboration with other divisions of the NCSCM. Research interests of ISE would include social aspects of the coastal management, traditional wisdom, and the regional and national level solutions for livelihood security and improved community level resilience against coastal hazards. The major groups under the ISE are: (i) the Coastal Livelihood and Demography, (ii) the Traditional Knowledge, (iii) the Employment and Education, (iv) the Coastal Community, Culture and Heritage, (v) the Regional Planning, (vi) the Coastal Conflicts Study, and (vii) the Coastal Ecosystem Economics.

Coastal Impact Assessment Division (CIA)

This division would provide input and advice on all components of coastal environment impact assessment. The division would study all relevant aspects to establish baseline environmental conditions of specific coastal areas. It would study the cumulative environmental, economic and social effects of regional development prospects on coastal and marine resources and environment. This Division would suitably advice management measures for Ecologically Sensitive Areas in the coastal and marine areas. The major groups under the division are: (i) the Coastal and Marine Sciences, (ii) the Coastal and Marine Engineering and Infrastructure, (iii) the Cumulative Coastal Environmental Impact Assessment, (iv) the Social Assessment and Gender, and (v) the Coastal Tourism and Heritage.

Conservation of Coastal and Marine Resources Division (CMR)

The primary mandate of CMR would be to guide the use of the living and non–living natural resources for diverse and often conflicting sectoral activities, so that the continued viability of all aspects of resource usage and ecosystem health can be secured. The CMR will investigate the interactions between natural coastal

resources and the coastal communities, with a view to establish the level of sustainable utilization, and thereafter the adoption of conservation ideas in the integrated coastal zone management plans in the country. The major groups under the division are: (i) the Coastal and Marine Living Resources Group, (ii) the Coastal and Marine Non-Living Resources Group, (iii) the Coastal Energy Group, and, (iv) the Marine Protected Areas Group.

Knowledge, Governance and Policy Division (KGP)

This division will work as a central repository for the dispersed information on the Indian coast. Coastal management requires all the stakeholders to be interconnected at different scales in order to share information, knowledge and data to solve problems and conflicts facing the coastal area and livelihood of the coastal communities. The knowledge management system of the centre would assist those interested in coastal governance to access the most relevant information of coastal issues. This division would also provide advisory to the government on coastal governance and policy issues. The major groups under the division are: (i) the Information Bank, (ii) the Communication and Dissemination Group, (iii) the Capacity Building Group, (iv) the Coastal Law and Policy Group, and, (v) the Partnership and Networks Group.

Futuristic Research Division (FTR)

FTR would conduct advanced research on climate change and sea level rise issues including paleo-climatic issues; offshore energy; future development potential of the coastal and marine areas and the islands; long-term adaptation plans aimed to achieve increased resilience to coastal hazards. In additional, the division would undertake research to enhance the resilience of the island communities; will help in building regional capacity in risk management, and prepare long-term guidelines for integrated coastal management plans. The major groups under the division are: (i) the Climate Change and Sea Level Rise Group, (ii) the Coastal Hazards and Mitigation Group, (iii) the Nano-Science and Ocean technology Group, and, (iv) the Island Ecology and Communities Group.

Integrated Island Management Division

The Integrated Island Management Division (IIM) would prepare a model framework for integrated island management plan. The goal of the IIM is to help ensure the future socio-ecological sustainability of the Indian islands, Andaman and Nicobar and the Lakshadweep by preparing an Integrated Island Management Plan. The IIM would undertake scientific approaches, coupled with indigenous knowledge for the better management of the islands and its resources. The IIM would consider the indigenous governance structures and knowledge - particularly in tribal dominated islands. The islands being pristine areas, this division would undertake long-term historical analysis including monitoring of the oscillations of crucial environmental variables.

The IIM would develop guidelines for hazard preparedness and evolve climate change adaptation and mitigation strategies for the Islands. Some of the major goals are to develop integrated island management / green island economy concept and to explore, in conjunction with island populations, ecotourism development as a particular option. The IIM would provide tools for mainstreaming Disaster Risk Management based on experiences from selected island countries worldwide. The IIM division would undertake specific research to enhance the resilience of the island communities; will help in building regional capacity in risk management, and prepare long-term guidelines for integrated coastal management plans.

Consortium Partner Institutions

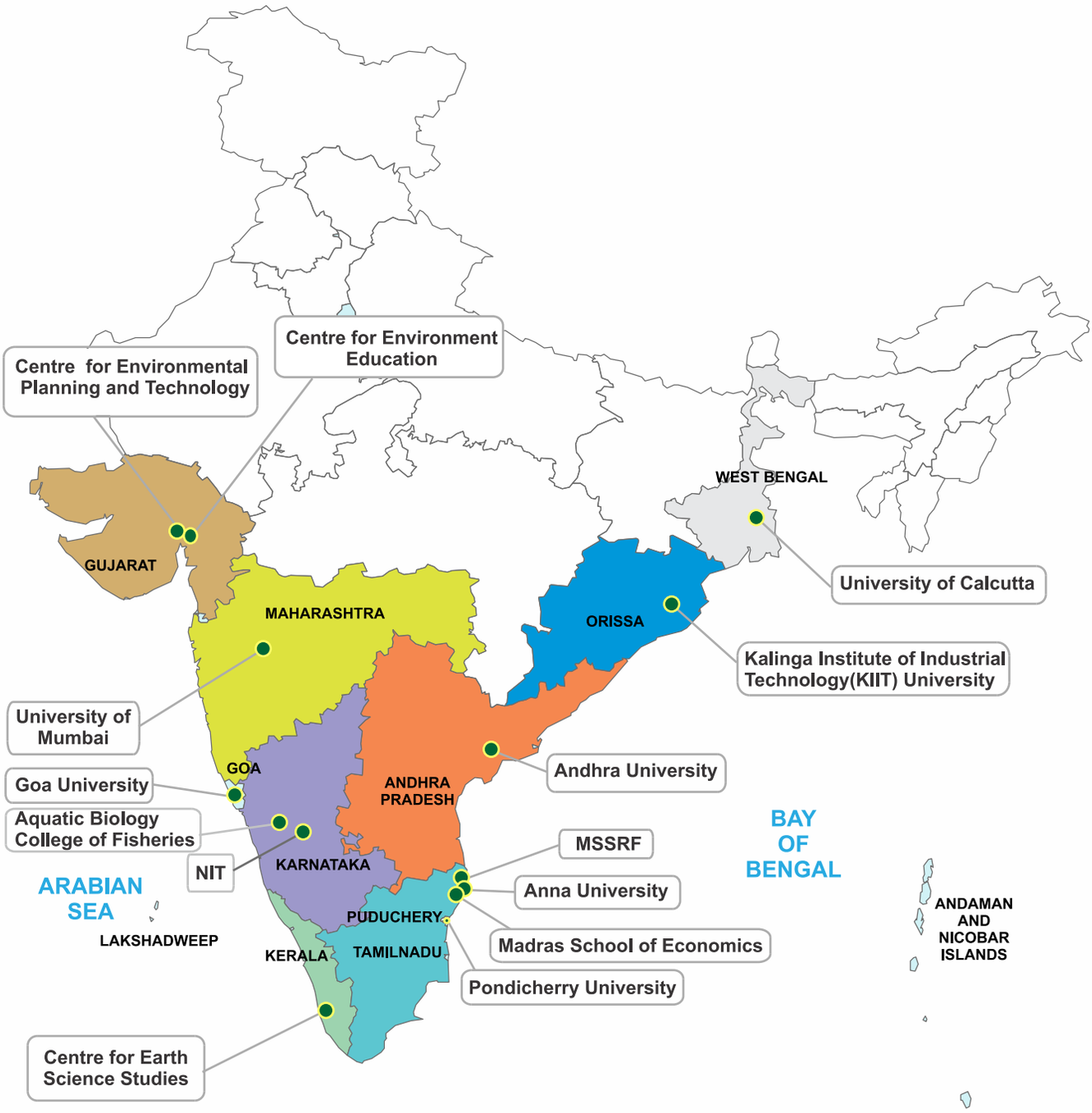
The Ministry of Environment and Forests recognized that the issues related to the coast are too diverse and complex to be addressed by one research organization and hence there is a need to strengthen the capacity of regional universities and research units along the coast so as to be the research consortium partners of NCSCM, Chennai. The idea is novel and NCSCM is the first central research consortium organization to have such a focussed collaboration with regional universities.

Fourteen institutions have formed a consortium with the National Centre for Sustainable Coastal Management, Anna University Chennai and signed the Anna University declaration on 21st June 2010 to that effect. The salient features of the Declaration are :

1. Preparing immediate preventive and remedial action, wherever possible, using existing knowledge, resources, plans and processes for conservation and protection of the coastal environment and safeguarding the livelihood of local communities who depend upon the resources from the coastal and marine areas.
2. Promoting access and undertaking high quality targeted research in the area of coastal and marine area management and facilitating transfer of technology and information
3. Collecting compiling and disseminating information in the area of coastal and marine environment management through networking among States/ Institutions.
4. Encouraging cooperative and collaborative action and partnerships, among governmental institutions and organizations, communities, the private sector and non-governmental organizations which have relevant responsibilities and/or experience;
5. Assisting institutional strengthening and human resources development for capacity building in ICZM.

NCSCM has put in place a road map for strengthening and expanding the existing NCSCM consortium, stakeholder network and prioritize the community interface. NCSCM supports its partner consortium institutes by strengthening their core area of research, and build capacities on the core research mandates of the NCSCM. Such networks and partnerships will formalize multidisciplinary interactions in order to effectively address key coastal research problems. Research proposals are being prepared by the CIs jointly with the scientists of NCSCM in order to address the coastal issues through systematic research.

NCSCM
Consortium of Coastal Institutions



Research Programmes

NCSCM has undertaken pioneering study on various areas of immediate concern to aid in furthering the objectives of scientific management of the Indian coast.

NCSCM is developing a conceptual framework and process guidelines for ICZM in order to help the coastal state governments in preparing the detailed ICZM plans. The major research programmes of NCSCM are:

1. ICZM Process Guidelines: A roadmap towards coastal sustainability
2. National Assessment of Shoreline Change for India
3. High Resolution Erosion Mapping
4. Sediment Cell Mapping and development of SMP
5. Coastal Ecosystem Health Assessment & Report Card
6. Offshore Wind Energy Potential

In addition to the above, in the light of the emerging research issues related to coastal protection and the need for systematic study, the High Power Research Steering Committee (HPSC) of NCSCM has identified broad research areas for NCSCM and its consortium partners. Research projects have been prepared to undertake a comprehensive study on the identified areas. The projects thus identified are:

1. Blue carbon - Offsetting carbon emissions by conserving coastal vegetation
2. Delineation of Ecologically Sensitive Areas (ESA) and Critically Vulnerable Coastal Areas (CVCA)
3. Development of a database on marine diversity
4. Island Coastal Regulation Zone (ICRZ) Plan and Integrated Island Management (IIM) Plan for the Islands
5. Economic valuation of coastal and marine ecosystem goods and services in India
6. Inventorization of greenhouse gases from different coastal ecosystems

The research achievements under these projects are summarized in the following sections.

Knowledge, Governance & Policy

ICZM Process Guidelines:
A Roadmap towards Coastal Sustainability

The coast is a high priority area for development activities spurred by globalization and trade requirements. Since most development activities are sectoral and highly competitive, there is often conflict for space and resources. The pressure on natural ecosystems is high and has resulted in extensive destruction and degradation of coastal ecosystems in the recent past. In order to achieve sustainable development of the coast, integrated coastal zone management [ICZM] has been recommended as a tool. ICZM is a planning and coordinating process, where the primary purpose is to bring together various concerned agencies to work towards common objective[s].

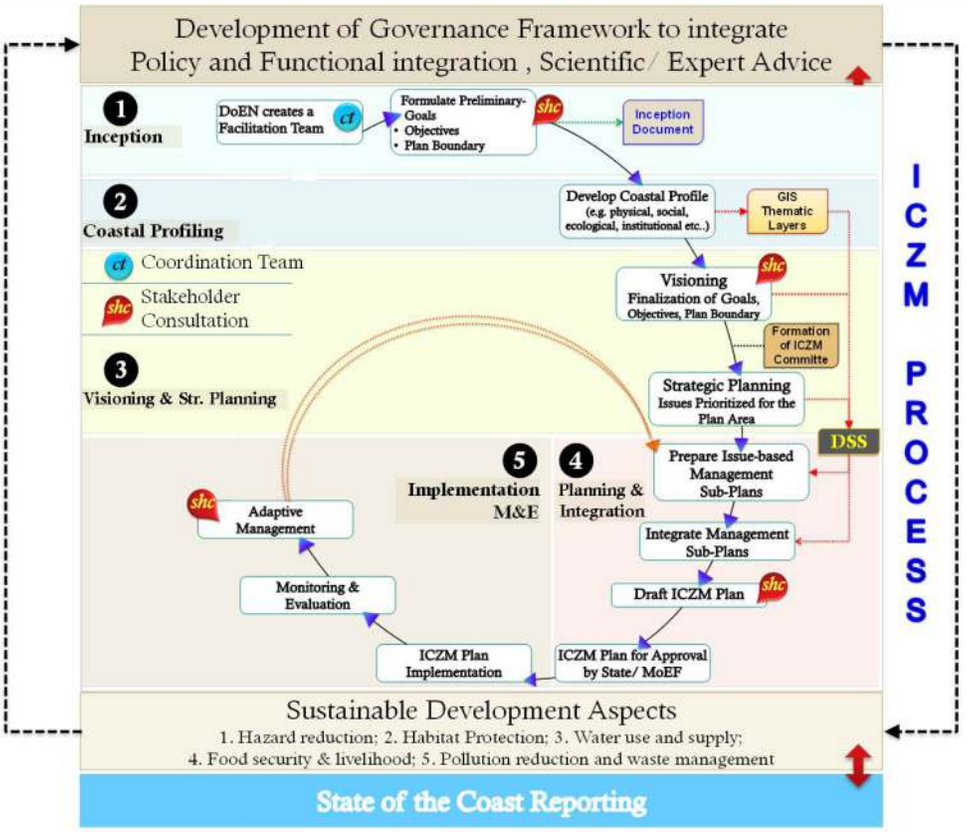
In India, since 1991, the Notification issued under the Environment [Protection] Act, 1986 has been used for coastal protection by classifying a 500m zone from the high tide line as the Coastal Regulation Zone, [CRZ] where [development] activities are severely restricted. The notification was reissued in 2011. While managing the coastal area has to be firmly rooted in the legislation, the 500m boundary is not always practical or meaningful for managing the coastal area as impacts on the coast can originate beyond the 500m that is regulated. ICZM provides a larger perspective for development-related activities as well as conservation of coastal ecosystems. The coast is also a highly vulnerable area especially with reference to impacts of climate change and sea level rise. There is also conflict for space and resources. Working within the constraints of limited space for competing resources, ICZM can help by providing a mechanism along with tools that allow development activities underscored by the precautionary principle while ensuring rational resource allocation and conservation of ecosystems. It also ensures incorporation of environmental and social concerns in the developmental activities.

The process of preparing an ICZM plan is discussed (Fig. 1) under the following five phases:

- **Phase I** Inception
- **Phase II** Coastal Profiling
- **Phase III** Visioning and Strategy Formulation
- **Phase IV** Planning and Integration
- **Phase V** Implementation, Monitoring & Evaluation

Capacity building is built into each phase and would vary depending on the stakeholder and the task to be performed. Similarly, various tools are available that can be used in supporting the different tasks in the preparation of the ICZM Plan.

Fig. 1:The ICZM Process Framework



Phase I

The "Inception" Phase is designed to provide the foundation for the development of an ICZM Plan. It begins with the formation of a Facilitation Team [FT] by the nodal department [e.g. Department of Environment], which coordinates the activities through the entire process. The FT may take the assistance of external agencies/institutions at various stages in the process. The initial activity carried out by the FT is to outline the plan boundary [ICZM planning area], the preparation of a background note on the major problems in the plan area as well as a brief profile of that plan area [resources, livelihoods, developmental activities [such as ports, industries] and a list of stakeholders which includes the local coastal communities. Since a variety of stakeholders with different levels of knowledge and understanding are to be involved, an awareness campaign and capacity building exercise has to be organized for each group of stakeholders before holding a combined stakeholder consultation that discusses the key issues in the plan area, broadly defines goals and objectives and the plan boundary. An inception report is then prepared.

Phase II

The second phase is 'Coastal Profiling'. The first activity here is collection and collation of information on the physical features of the coast, coastal processes, resources, land use and land cover and socio-economics with special focus on coastal livelihoods and the dependence of local communities on natural resources. This information would provide a broad overview of the land-people-ecosystem interactions and enable derivation of the important issues, their causes, priorities, and consequences, in

order to provide a scientific basis for developing a strategic management plan for the area. This would be prepared in a GIS format to enable the development of a "Decision Support System" during plan preparation as well as implementation. The second activity in this phase is a review of the legal and institutional framework governing the region. The outcome of this review would help analyze and identify if possible, the key stakeholder institution for plan implementation. This would also help ensure the capacity of the institution/ organization to further implement the ICZM Plan. The third activity in this phase is the collection of department/agency-wise [sectoral] plans for the region. The entire process is reviewed by an ICZM Committee [ICZM-C] constituted by the Nodal department.

Phase III

The activities in Phase III, 'Visioning and Strategy Formulation' are geared towards the development of a stakeholder vision based on which a "coastal strategy" is formulated. The visioning process is a step-wise activity that ensures the involvement and eventual consensus of all stakeholders in the plan area on the development, socio-economics and conservation priorities. Once a vision is agreed upon, the stakeholders could work on how to realize the vision. This would result in the development of a coastal strategy. The goals and objectives as well as the plan boundary that were outlined in Phase I, are redefined/modified [if necessary] and formally accepted. The issues to be addressed by management sub-plans that focus on addressing the issue identified as being of priority. Examples of such sub-plans would include those for shoreline management; pollution management and conservation are identified and listed. These would be reviewed by ICAM Committee

Phase IV

In Phase IV, 'Planning and Integration', continues from Phase III and first involves the development of management sub-plans with input from the departmental/agency plans for the area. Gaps identified are filled to prepare individual sub-plans. For areas with multiple issues, it is expected that there will be multiple sub-plans. Preparation of sub- plans involve detailed analysis of issues [through collection of field data] and development of solutions to solve problems including the cross-sectoral impacts. These sub-plans are now integrated into a single draft ICZM plan by examining them for congruence, and overlaps after resolving inter-departmental conflicts. The plan is also aligned for financial/budgetary allocations. An institutional structure for implementing ICZM Plan is developed and a strategy to monitor the plan implementation is formalized. The integrated plan for the chosen area is presented to the key stakeholders/ community and the feedback is incorporated into the draft ICZM plan. The draft plan is reviewed by ICZM-C before finalisation. The plan also recommends appropriate legal coverage/ Notification to ensure its implementation. This is submitted to the State Government as well as to the MoEF for approval.

Phase V

The final Phase, 'Implementation, Monitoring and Evaluation', includes Implementation of the ICZM plan by respective departments / agencies, Monitoring and Evaluation using appropriate indicators and adaptive management, to take corrective steps where required. Thus, ICZMP also provides flexibility for change.

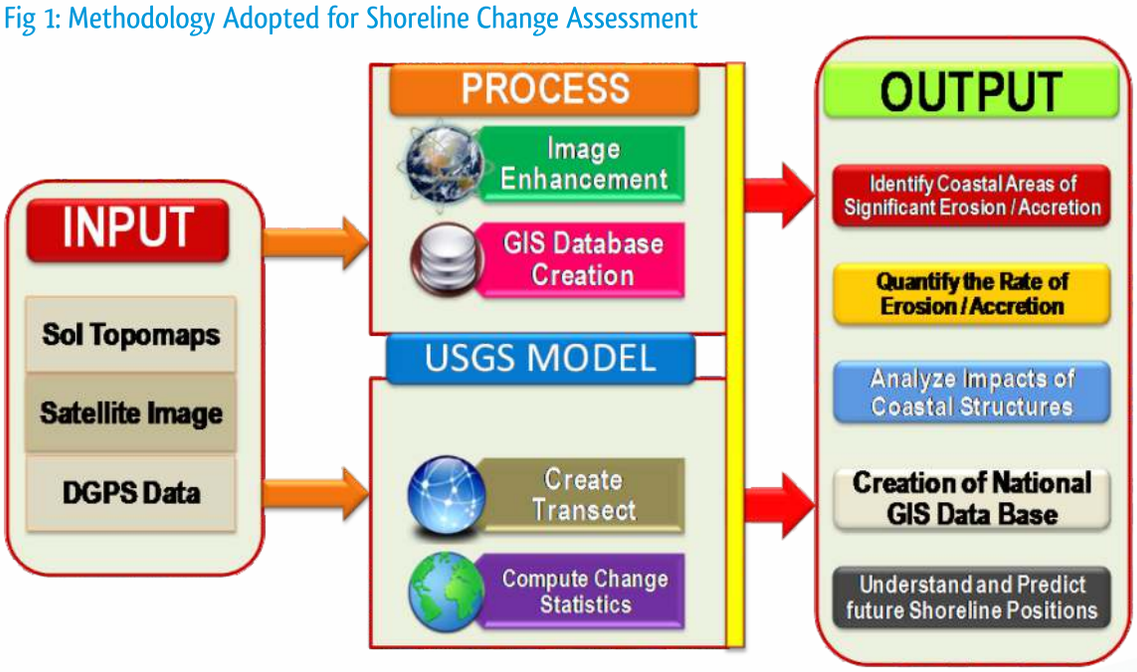
Geospatial Sciences

National Assessment of Shoreline Change for India

The National Centre for Sustainable Coastal Management, Ministry of Environment and Forests, in collaboration with the Institute for Ocean Management, Anna University, Chennai, undertook a major study of shoreline change for the entire coast of India in order to identify coastal areas where significant erosion and accretion have occurred and continue to occur, quantify the rates of erosion/ accretion, analyze the impacts of coastal structures on the shoreline, create a national database for coastal erosion and accretion with 1972 as the base year and contribute to an understanding and prediction of future shoreline positions. Earlier shoreline mapping and analyses were carried out by a manual cartographic technique which since early 1980s, has been changed to a highly sophisticated Geographic Information System (GIS). A GIS database has been created with layers such as base shoreline, historical shorelines, erosion rates, and critical erosion maps by state for the entire coastline of mainland India.. The goal is to develop a national inventory in GIS, which would serve as a Shoreline Change Database.

The study represents long-term shoreline change for a period of 38 years from 1972-2010. It summarizes the methods of analysis and provides explanations regarding long-term trends and zones of change. Shoreline change evaluations are based on comparing five historical shorelines extracted from satellite imageries for the above time period, with recent shoreline derived from LISS IV images. The historical shorelines represent the following periods: 1972 (Survey of India Toposheet) used as base map, satellite imageries of 1990, 2000, 2006 and 2010. The primary goal is to develop standardized methods for mapping and analyzing shoreline movement so that internally consistent updates can periodically be made to record shoreline erosion and accretion. Appropriate use of remote sensing technology coupled with limited DGPS surveys was integrated in GIS platform to obtain historical shoreline information. The rate of shoreline changes and the Erosion/ Accretion zones were calculated using Digital shoreline Analysis System (DSAS) a model compatible in GIS by U.S Geological Survey. The schematic for the quantification of shoreline changes in DSAS is given below:

Fig 1: Methodology Adopted for Shoreline Change Assessment



Mapping has been completed for all the coastal States (except Gujarat) and Union Territories (UT) along the Indian coast on a 1:50,000 scale. The shoreline change maps for the States of Kerala, Odisha, Tamil Nadu, Andhra Pradesh and the UT of Puducherry have already been approved by the respective state governments and the shoreline change maps are available online at http://www.ncscm.org, while the state approval for the maps for Maharashtra, Goa, Karnataka and West Bengal are awaited. The maps for the state of Gujarat is being revised.

Table 1: Summary of Shoreline Change Map Approval Status

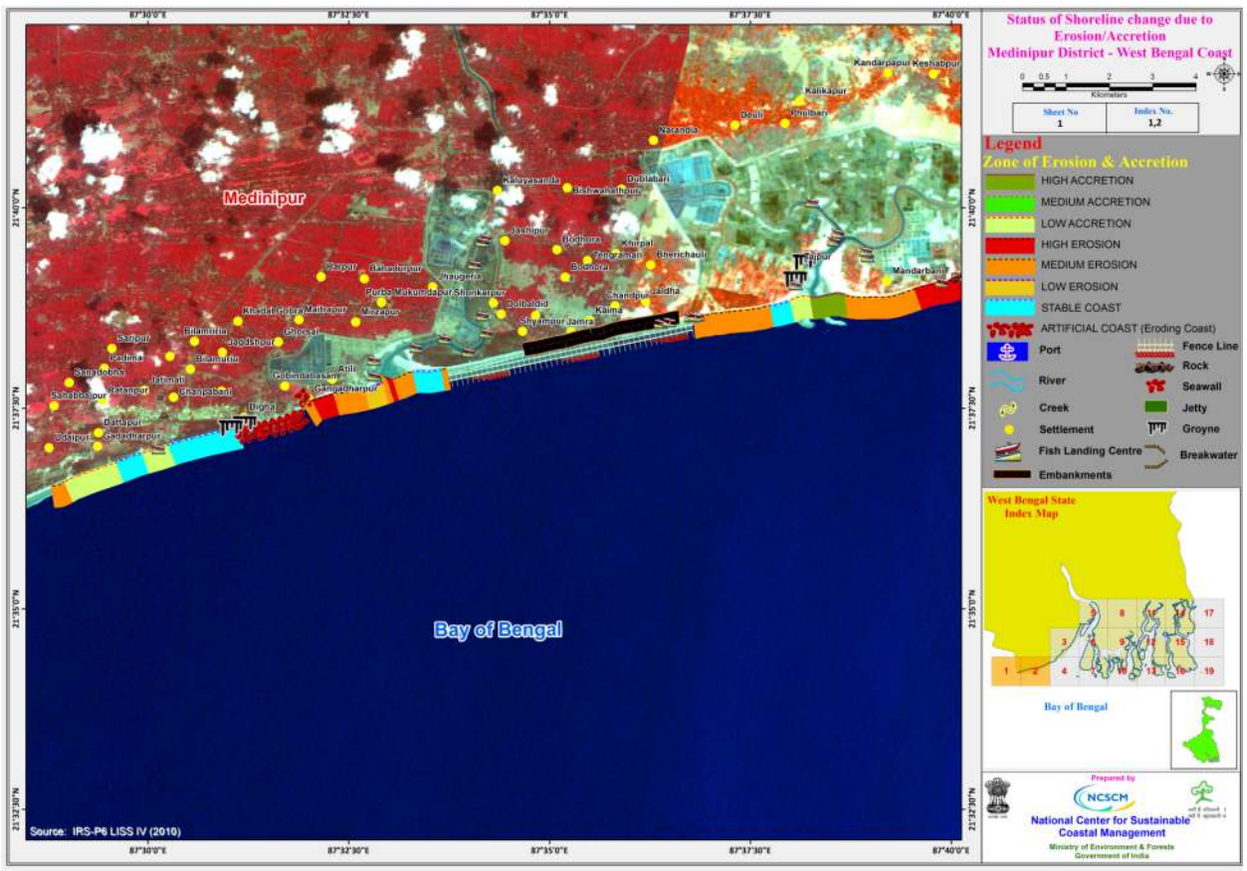
No.	State/ UT	Mapping	Presentation to the State / UT Government	Approval Status by State / UT Government
1	Gujarat	Mapping Completed	Completed	Approved
2	Maharashtra			Awaited
3	Goa		Maps Submitted	
4	Karnataka		Presentation made in July 2012 – feedback awaited	Awaited
5	Kerala		Completed	Approved
6	Tamil Nadu			
7	i. Puducherry ii. Karaikal			
8	Andhra Pradesh			
9	Odisha			
10	West Bengal			Awaited

Examples of shoreline change maps of specific sites in the individual coastal states/UT are shown below with key information of the coast and the extent of erosion/ accretion.

Key Information

Length of the coastline	:	220.06 km	No. of Breakwater	:	1
No. of Fish Landing Centre	:	39	No. of Groynes	:	6
No. of Ports/Harbours	:	3	No. of Jetties	:	-

Approval Status
Awaited

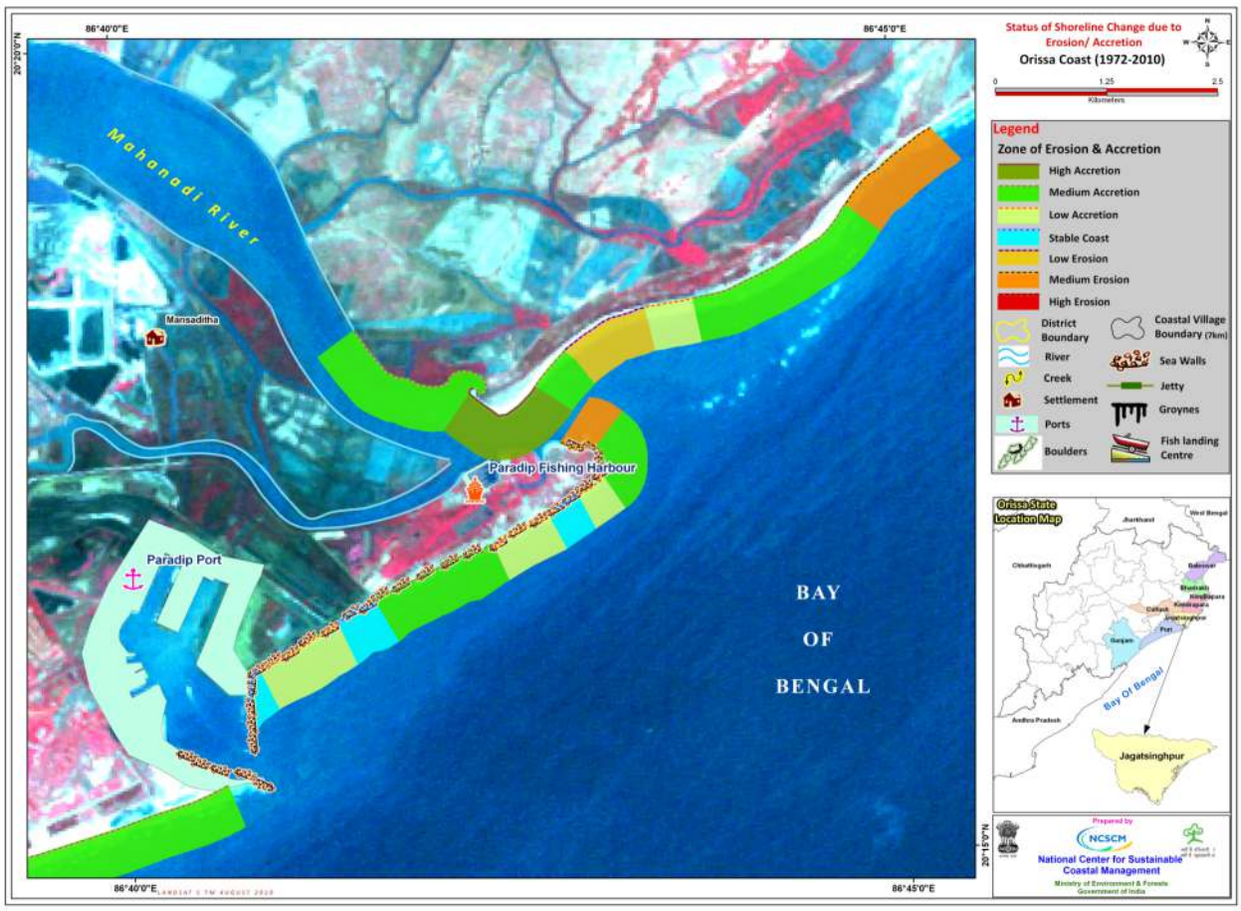


Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
9.43	3.29	9.43	22.35	9.17	0.96	13.96	34.28	4.95

Erosion in Digha coast, West Bengal

Key Information

Length of the coastline	: 480.4 km	No. of Breakwater	: 2	Approval Status	
No. of Fish Landing Centre	: 57	No. of Groynes	: 14	Approved	
No. of Ports/Harbours	: 13	No. of Jetties	: 8		



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
26.59	16.27	2.9	11.5	1.68	8.18	23.01	-	2.03

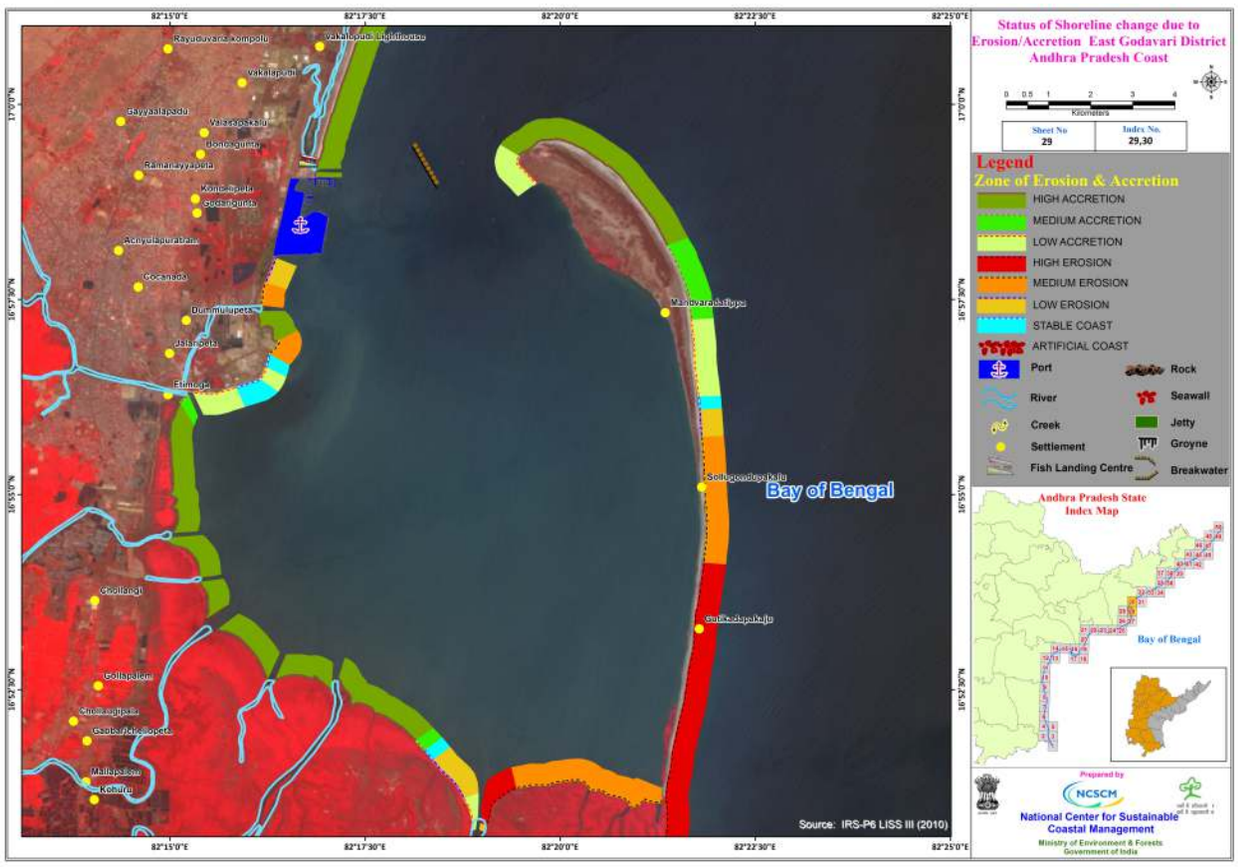
Erosion in Jagatsinghpur coast, Odisha

Key Information

Length of the coastline : 1008.37 km
No. of Fish Landing Centre : 267
No. of Ports/Harbours : 13

No. of Breakwater : 14
No. of Groynes : 2
No. of Jetties : 2

Approval Status
Approved



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
30.85	22.12	9.36	8.8	6.32	8.16	13.57	0.8	0.03

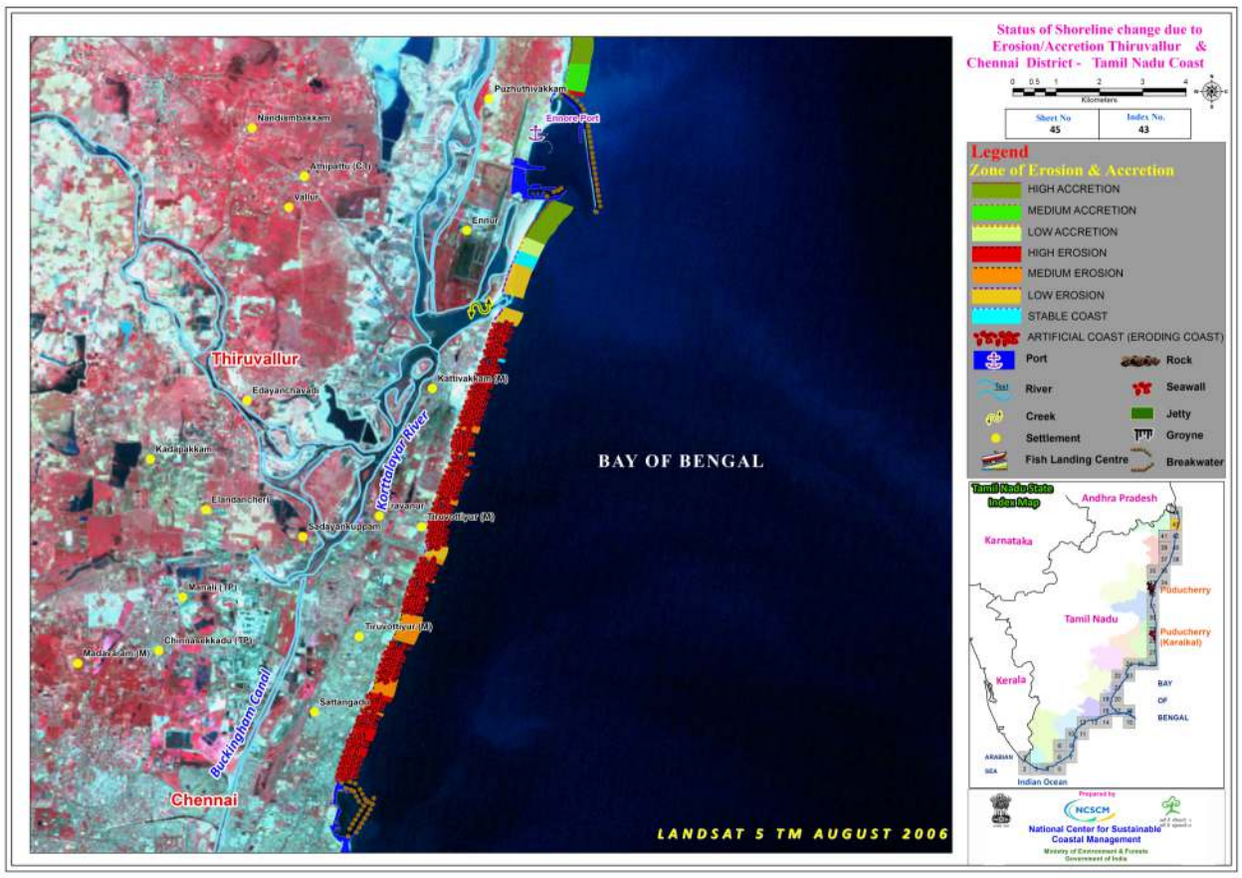
Sea Erosion along Kakinada – Uppada Beach Road, East Godavari Dt. AP

Key Information

Length of the coastline : 954.71 km
No. of Fish Landing Centre : 376
No. of Ports/Harbours : 7/9

No. of Breakwater : 3
No. of Groynes : 272
No. of Jetties : 20

Approval Status
Approved



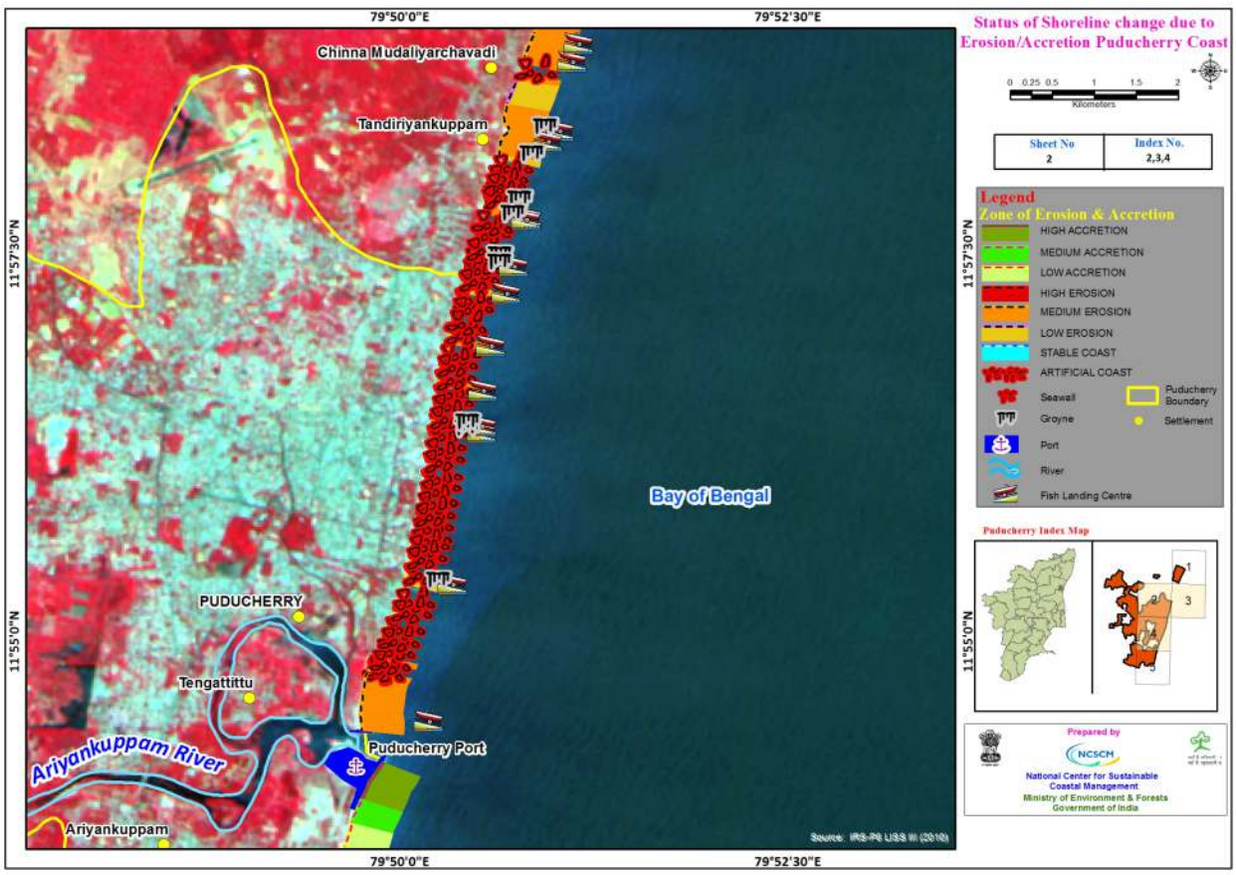
Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
3.1	13.4	20.8	28.2	11.1	1.1	19	0.5	2.8

Sea Erosion in Nettukkupam, North Chennai

Key Information

Length of the coastline : 19.36 km
No. of Fish Landing Centre : 52
No. of Ports/Harbours : 2
No. of Breakwater : 2
No. of Groynes : 7
No. of Jetties : 1

Approval Status
Approved



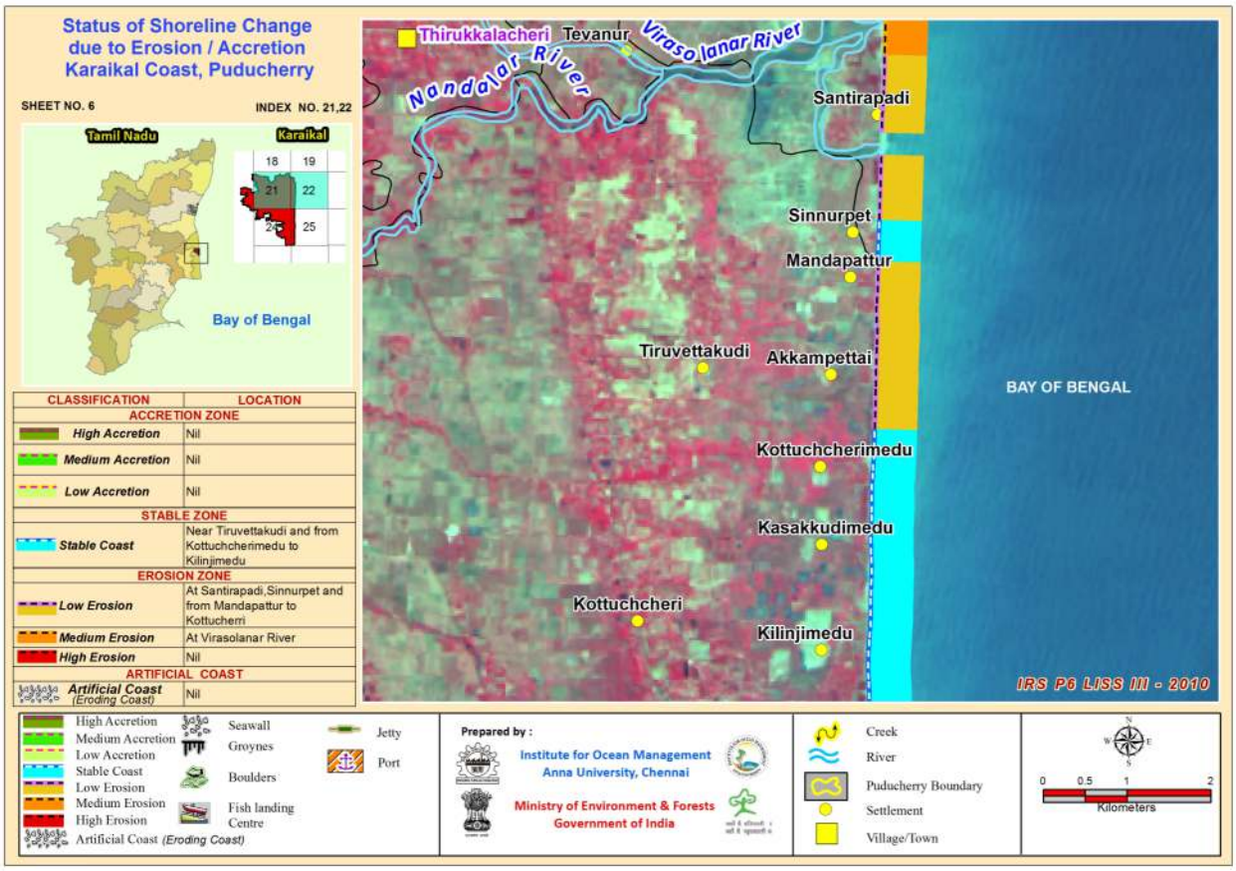
Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
2.6	1.5	11.1	27.3	8.5	-	26.7	-	22.3

Sea erosion in Soudanaikuppam village south of Aurovillie, Puducherry

Key Information

Length of the coastline : 15.17 km
No. of Fish Landing Centre : -
No. of Ports/Harbours : 1
No. of Breakwater : 2
No. of Groynes : 1
No. of Jetties : 1

Approval Status
Approved



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
1.98	-	-	45.55	49.64	-	0.43	-	-

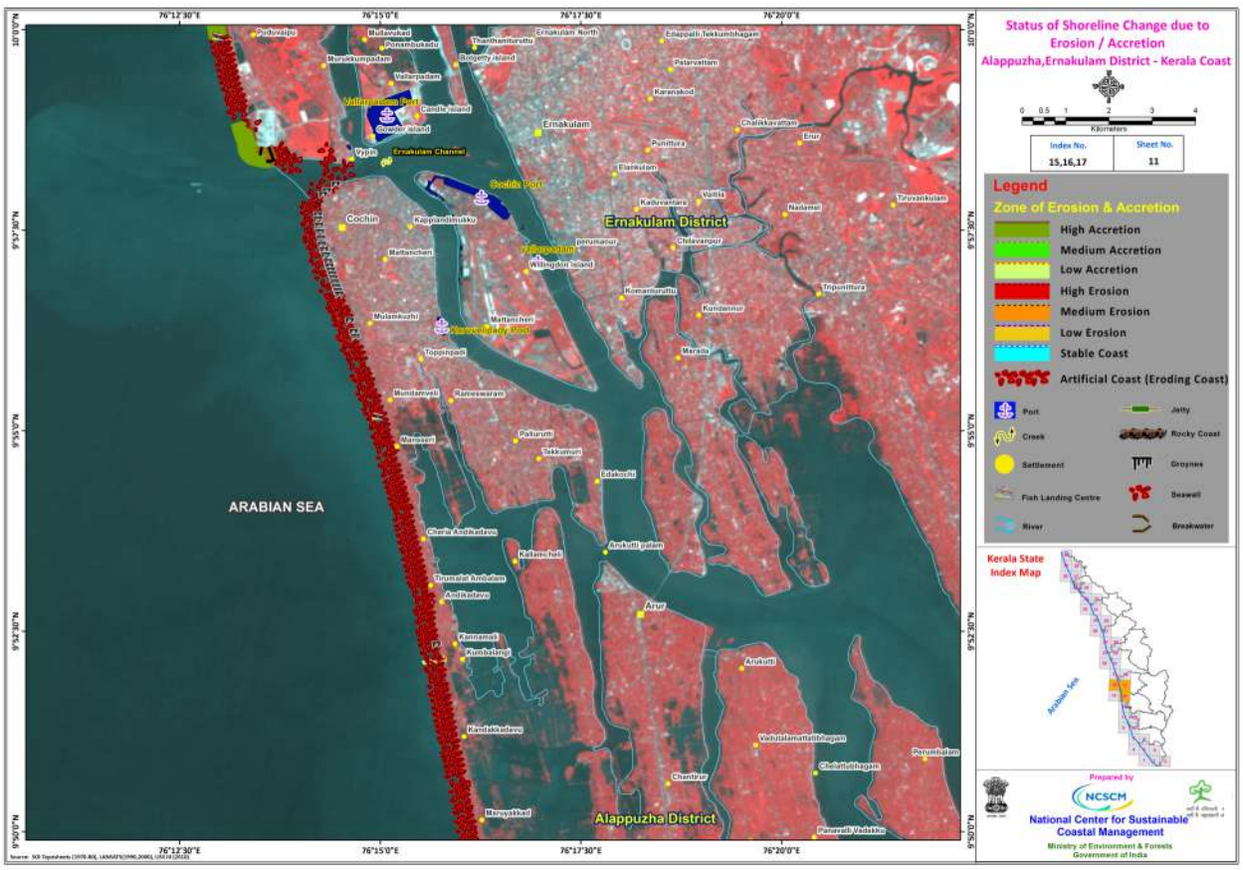
Erosion in Killinjam Medu Village, Karaikal

Key Information

Length of the coastline : 587.8 km
No. of Fish Landing Centre : 190
No. of Ports/Harbours : 17/11

No. of Breakwater : 25
No. of Groynes : 106
No. of Jetties : 25

Approval Status
Approved

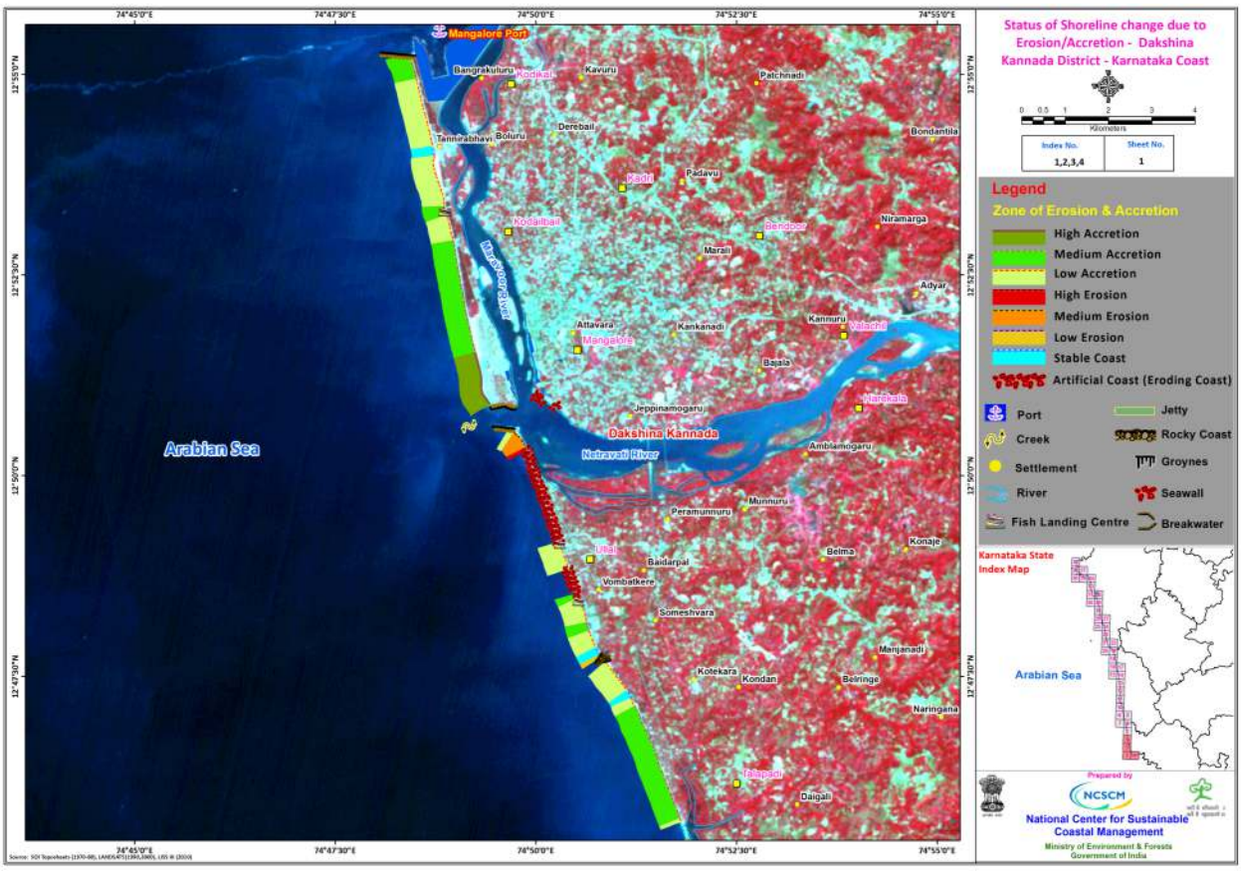


Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
4.9	9.03	9.98	8.37	1.57	0.40	7.87	5.18	52.69

Erosion in Chavvad Coast, Kerala Chavvad Beach

Key Information

Length of the coastline	: 297.90 km	No. of Breakwater	: 15	Approval Status	
No. of Fish Landing Centre	: 88	No. of Groynes	: 6	Awaited	
No. of Ports/Harbours	: 11	No. of Jetties	: 4		



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
17.5	7.8	1.7	16.8	1.8	-	14.5	24.8	15

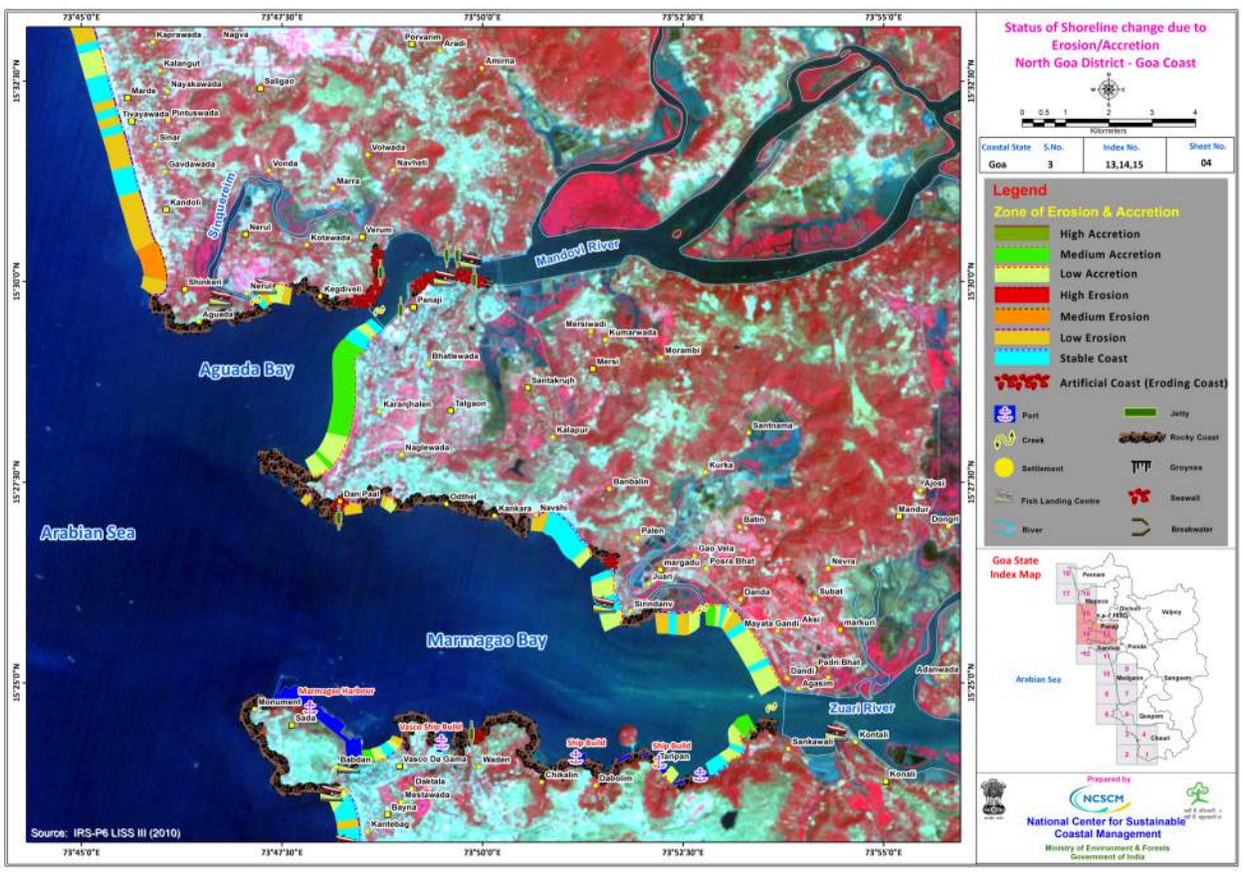
Erosion in Ullal coast, Karnataka

Key Information

Length of the coastline : 128.34 km
No. of Fish Landing Centre : 34
No. of Ports/Harbours : 6

No. of Breakwater : 4
No. of Groynes : -
No. of Jetties : 1

Approval Status
Awaited



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
10.2	2.9	-	14.9	3.2	-	14.9	53.1	0.9

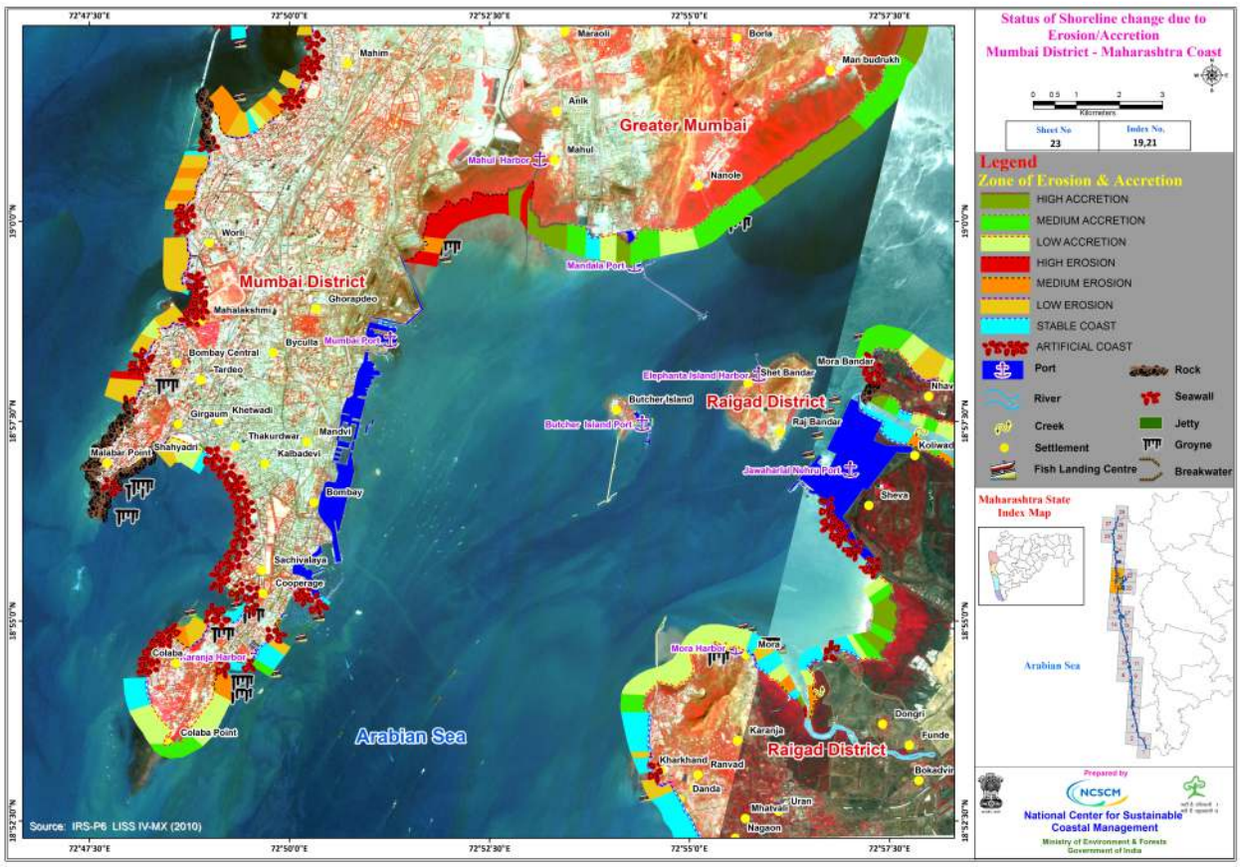
Erosion in Anjuna coast, North Goa

Key Information

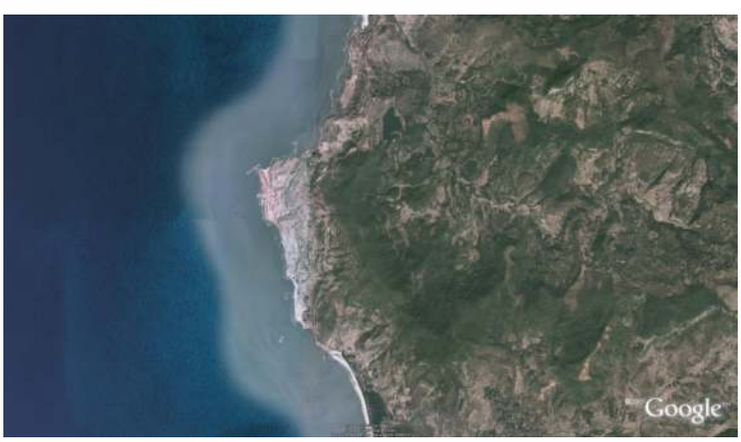
Length of the coastline : 720.56 km
No. of Fish Landing Centre : 86
No. of Ports/Harbours : 6/39

No. of Breakwater : 4
No. of Groynes : 207
No. of Jetties : 9

Approval Status
Awaited



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
9.43	3.29	1.62	22.35	9.17	0.96	13.96	34.28	4.95



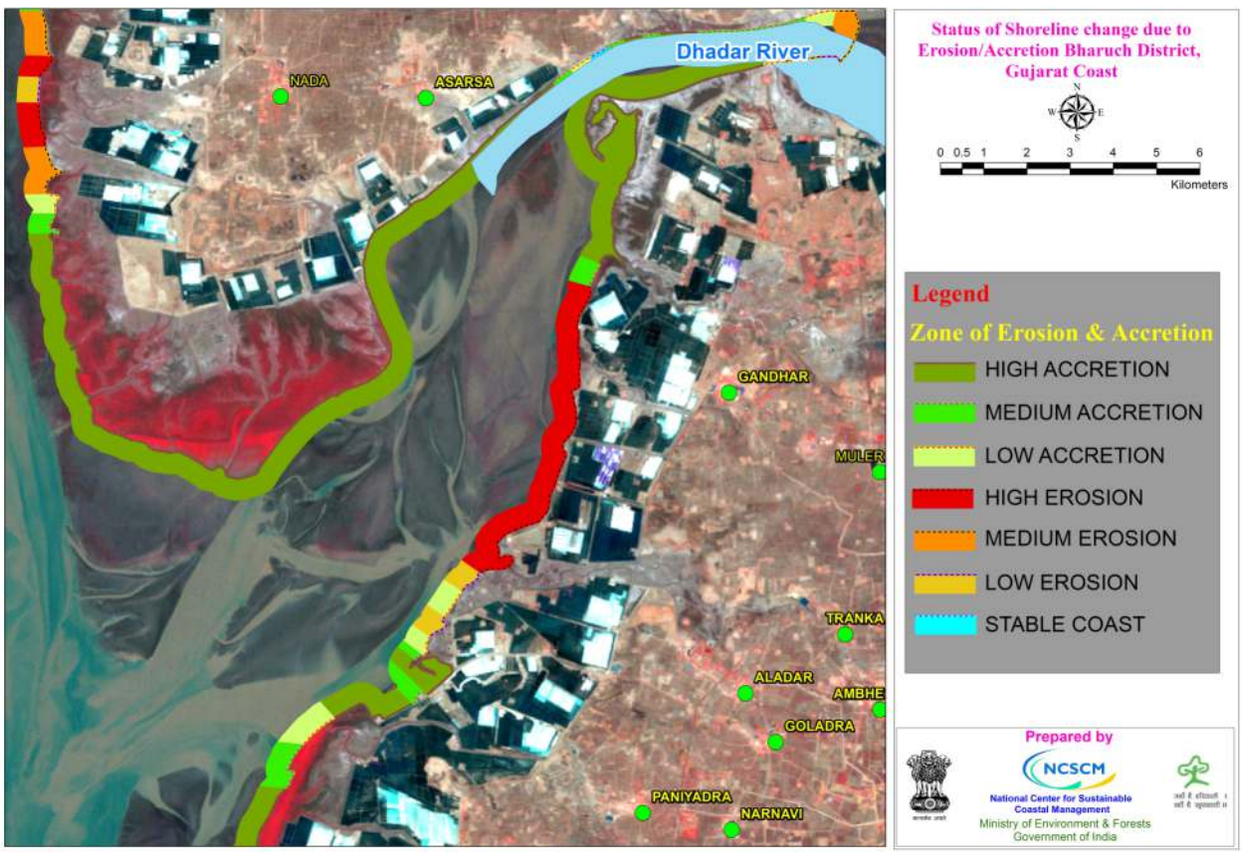
Erosion in Harihareshwar beach south of Mumbai

Key Information

Length of the coastline : 1600 km
No. of Fish Landing Centre : 67
No. of Ports/Harbours : 41

No. of Breakwater : 22
No. of Groynes : 4
No. of Jetties : 6

Approval Status
Approved



Accretion (%)			Erosion (%)			Stable (%)	Rocky(%)	Artificial (%)
Low	Medium	High	Low	Medium	High			
12.85	12.34	11.16	14.43	16.12	19.90	10.84	2.12	0.24

Erosion in Koliyak beach 25 km south of Bhavnagar

Table 2: Summary of Shoreline Change along the coast of India

No.	State	Length of the Coast mapped (km)
1	West Bengal	220.06
2	Odisha	480.40
3	Andhra Pradesh	1008.37
4	Tamil Nadu	954.71
5	Puducherry (Union Territory)	19.36
6	Karaikal (Union Territory)	15.17
7	Kerala	587.80
8	Karnataka	297.90
9	Goa	128.34
10	Maharashtra	720.56
11	Gujarat	1600.00
	Total	6032.67

Table 3: Overall statistics of the status of the shoreline of states/ UT
(Statistics for Gujarat is being revised)

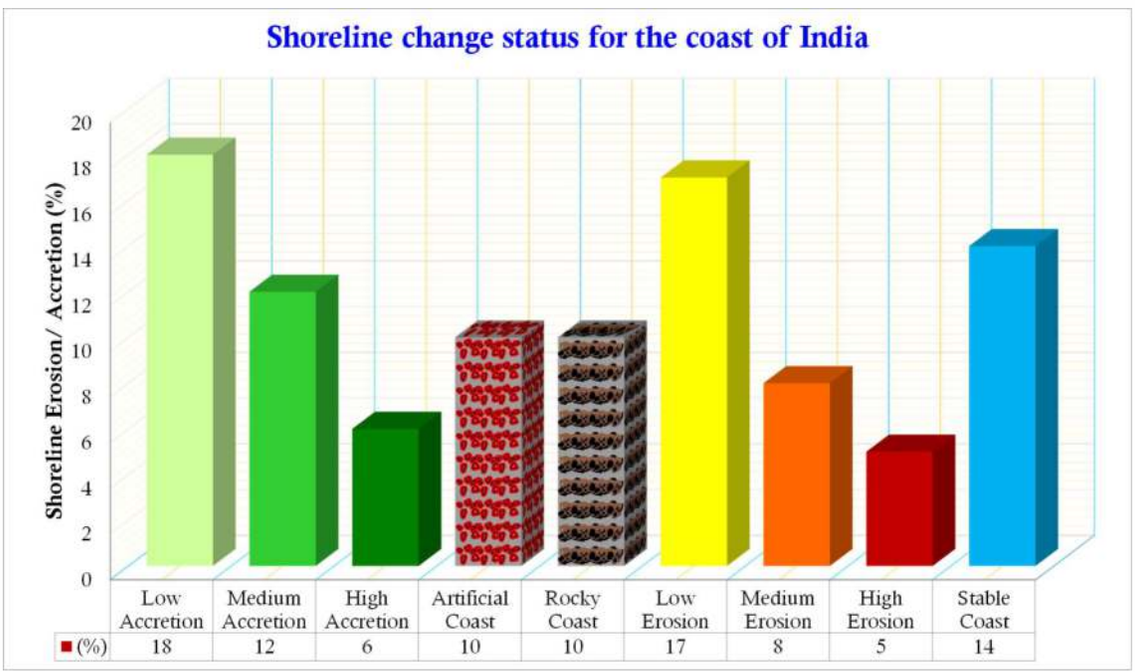
No.	State	Length of the Coast (km)	Extent (%)								
			LA	MA	HA	STB	AC (SW)	Rocky coast / Embankment	LE	ME	HE
1.	West Bengal	220.06	4.36	7.09	7.36	5.00	1.63	6.70	3.41	18.98	45.48
2.	Odisha	480.40	26.59	16.27	2.90	23.01	2.03	-	11.50	1.68	8.18
3.	Andhra Pradesh	1008.37	30.85	22.12	9.36	13.57	0.03	0.80	8.80	6.32	8.16
4.	Tamil Nadu	954.71	20.80	13.40	3.10	19.00	2.80	0.50	28.20	11.10	1.10
5.	Puducherry (UT)	19.36	11.10	1.50	2.60	26.70	22.30	-	27.30	8.50	-
6.	Karaikal (UT)	15.17	1.98	-	-	2.83	-	-	45.55	49.64	-
7.	Kerala	587.80	9.98	9.03	4.90	7.87	52.69	5.18	8.37	1.57	0.40
8.	Karnataka	297.90	17.50	7.80	1.70	14.50	15.00	24.80	16.80	1.80	-
9.	Goa	128.40	10.20	2.90	14.90	14.90	0.90	53.10	14.90	3.20	-
10.	Maharashtra	720.56	9.43	3.29	1.62	13.96	4.95	34.28	22.35	9.17	0.96

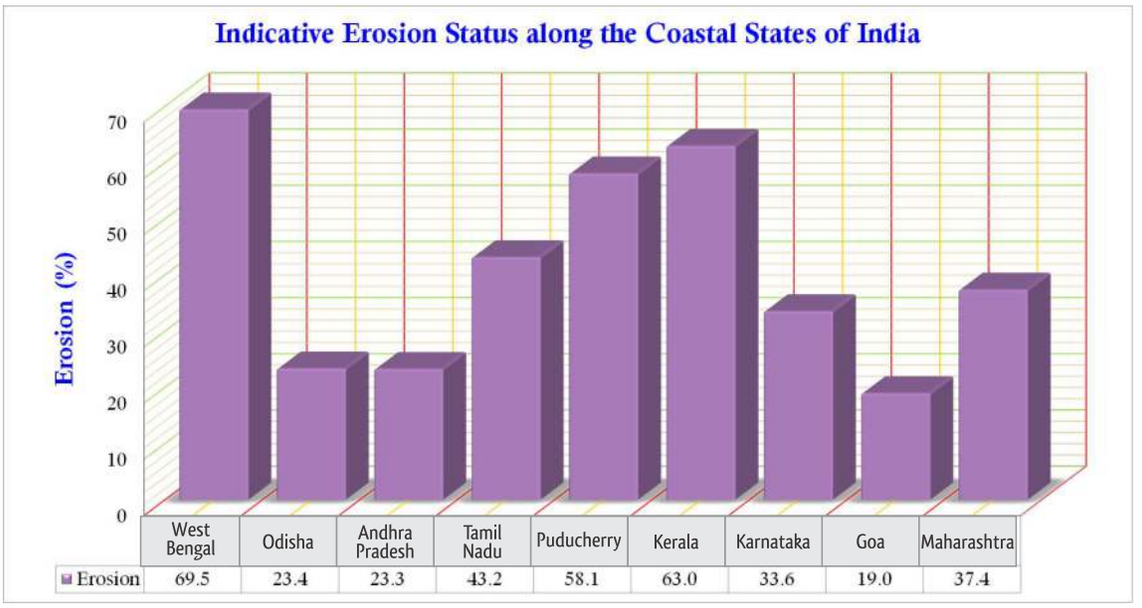
LA - Low Accretion; LE - Low Erosion; MA - Medium Accretion; ME - Medium Erosion; HA - High Accretion; HE - High Erosion; STB - Stable Coast; AC (Seawall) - Artificial Coast; RC- Rocky Coast

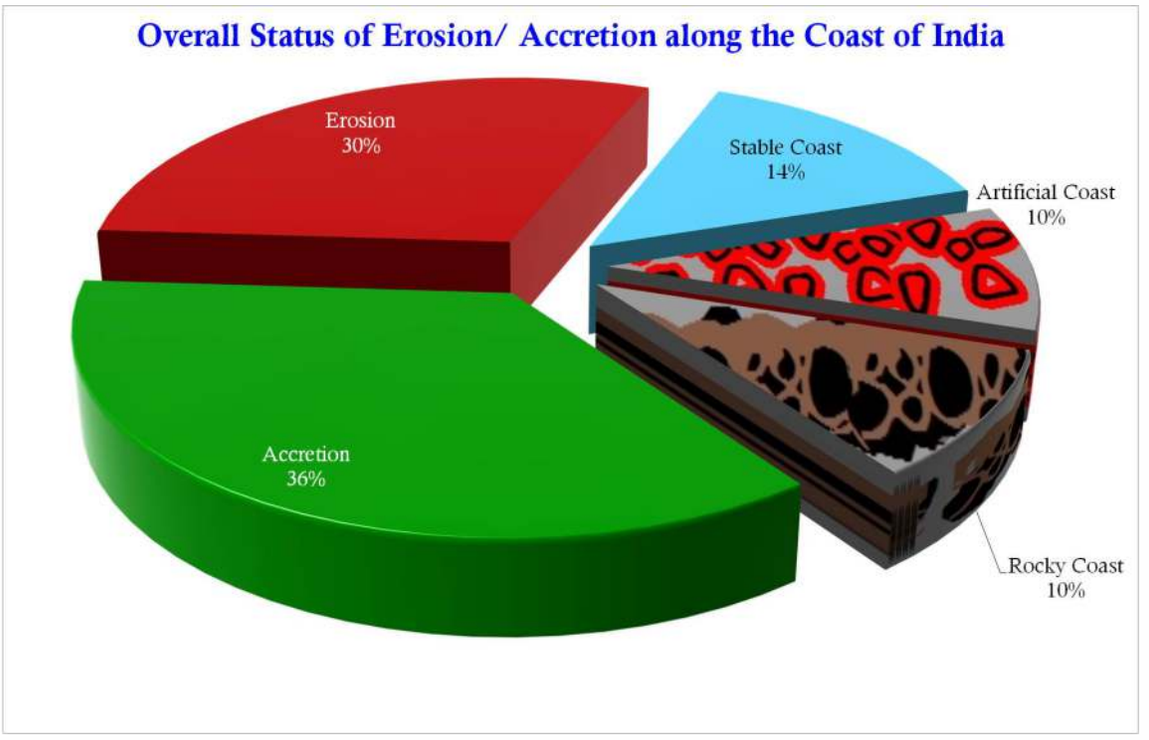
Table 4: Overall status of the shoreline for Peninsular India

Shoreline status	Length	
	km	%
Low Accretion	797.65	18
Medium Accretion	525.60	12
High Accretion	272.43	6
Artificial Coast	612.62	10
Rocky Coast	436.18	10
Low Erosion	446.87	17
Medium Erosion	742.08	8
High Erosion	357.48	5
Stable Coast	241.76	14
Total	4432.67	100

Shoreline Status of Peninsular India (except Gujarat as the statistics is being revised)



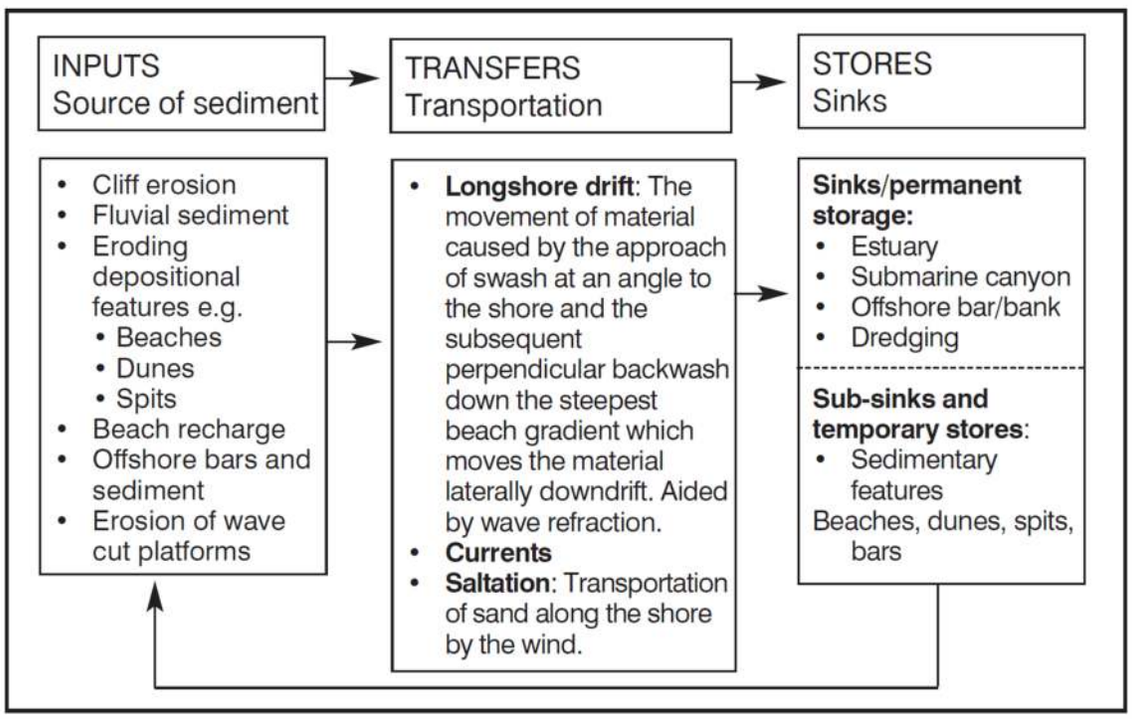

Indicative Erosion Status along the Coastal States of India
Erosion (%)
70
60
50
40
30
20
10
0
West Bengal
Odisha
Andhra Pradesh
Tamil Nadu
Puducherry
Kerala
Karnataka
Goa
Maharashtra
Erosion
69.5
23.4
23.3
43.2
58.1
63.0
33.6
19.0
37.4


Overall Status of Erosion/ Accretion along the Coast of India
Erosion
30%
Stable Coast
14%
Artificial Coast
10%
Accretion
36%
Rocky Coast
10%

Delineation of Sediment cells

As a part of the ICZM process, the drive to understand coastal sediment budgets and their inter-relationship with coastal management schemes has led to the adoption of coastal sediment cells and subcells as basic units of coastal zone management in India. One of the main activities of the coastal system is the sourcing, transfer and deposition of sediment along a stretch of coastline called a "sediment cell" (Fig. 1). A typical sediment cell is defined as "a length of coastline and its associated nearshore area within which the movement of coarse sediment (sand and shingle) is largely self-contained. Interruptions to the movement of sand and shingle within one cell should not affect beaches in a neighbouring sediment cell" (DEFRA)[1].

Fig. 1: Sources of sediment, transfers and sediment sinks and stores within sediment cells (after Prentice, 2008)[2]

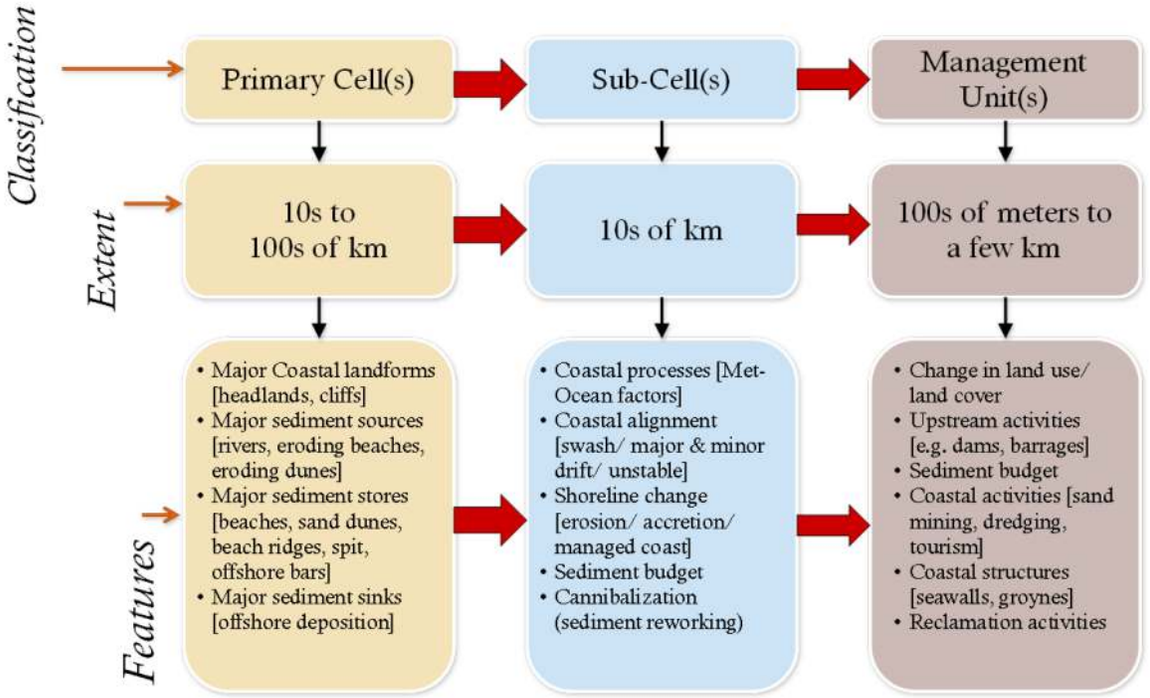


Sediment cell theory is a key component of shoreline management plans, which determine future strategies. There are three key scales of sediment cell delineation – i) primary cell, ii) sub-cell and iii) management units (Fig. 3). The primary cells are large scale and the dividing points are the headlands, around which almost no sediment can pass, or embayment that act as sediment sinks. Within these cells are subcells; some are of short length where the coastal alignment reverses the direction of drift. In terms of shoreline management plans, the subcells are the most important units, but maintaining the natural integrity of the primary cells is a consideration, based on the principle that any interference with long shore drift can disadvantage coast, coastal stability and downdrift. Further classification of the sub-cells into "management units" is made using the land use as major criteria (Fig.2).

[1] DEFRA: www.DEFRA.gov.uk

[2] Prentice, L. (2008) Coastal Systems: Waves, Tides, Sediments, Cells. Geofile Online © Nelson Thornes 2008 http://www.geographylwc.org.uk/A/AS/coasts/pdf/GF575_GF575.pdf

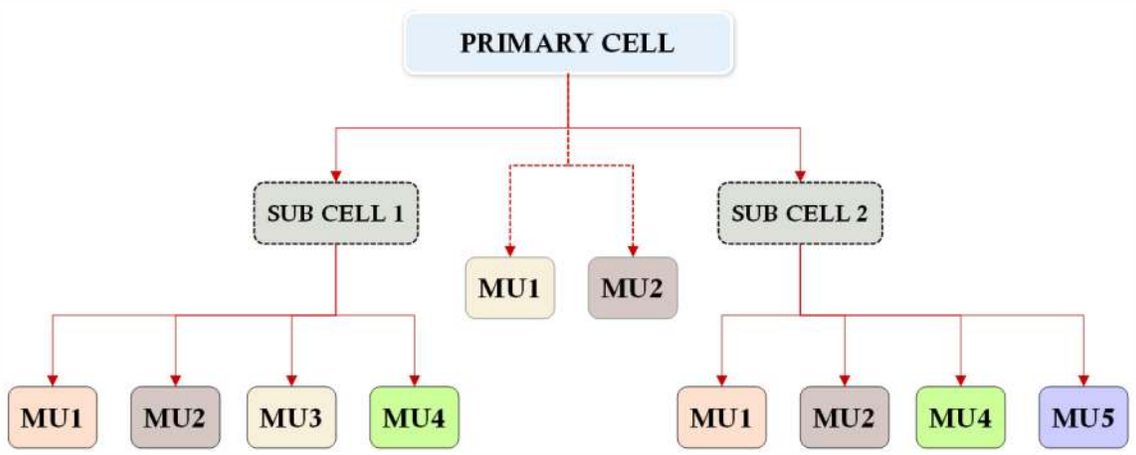
Fig. 2: Classification, extent and features of sediment cell delineation



Human activity can interfere with the processes within a sediment cell by disrupting the supply of sediment and therefore the sediment budget of the cell. Groynes, jetties and harbour walls will block the movement of sediment, which can lead to coastal erosion further downdrift. Sediment input supply can also be disrupted by river dams, which cut down on the amount of fluvial sediment entering the coastal system.

The expert members reviewed critically on the aspects of various criteria adopted for the delineation of Primary Cells, Sub-cells and Management units. The members also reviewed the boundary of Sub-cells and Management units by integrating with coastal process studies, the position of deployment of field equipments and profile survey. Detailed discussions were held and the following are the recommendations of the Expert Group.

Fig. 3: General classification sediment cells



The Primary Cells, Sub-cells and Management Units delineation were redefined and the criteria laid down are given below.

Primary Cells

Primary Cells delineation would be based on four major criteria as follows:

1. Coastal Geomorphology
2. Sources of Sediments
3. Stores of Sediments
4. Interface of Rocky Sandy – Muddy Coast.

Sub- Cells

The criteria for the delineation of Sub-cells would be based on five key criteria:

1. Changes in littoral drift
2. Change in coastal alignment
3. Erosion/ accretion (decades)
4. Manmade littoral barrier
5. Tidal inlets/ river mouths

Management Units

The criteria for delineation of Management Units are given below:

1. Coastal land use
2. Fishing related activities
3. Erosion/ accretion & protection measures
4. Proposed development plans
5. Sediment input rivers
6. Industries
7. Settlements
8. Tourism
9. Other coastal activities
10. Pollution, salt pans, aquaculture, salt water intrusion
11. Dredging, reclamation
12. Sand mining etc
13. Marine Protected Areas
14. Ecologically Sensitive Areas
15. Elevation
16. Defence related activities
17. Archaeological and Historical sites
18. CRZ

Delineation of Coastal Sediment Cells (Primary cells, Sub-cells and Management Units) was undertaken in order to develop an overall Shoreline Management Plan. Delineation of Primary cells for the entire mainland of India was done by studying the coastal processes (wave/wind/current, littoral drift pattern, sediment budget and bathymetry), shoreline change mapping and identifying coastal structures.

The sub-cell and the management units have been delineated so far for two states - Odisha and West Bengal. The primary cells and the subcells demarcated for the coast of Odisha are given in Figs 5 & 6. One of the subcells within the primary cell in Odisha (22a) along with the geomorphic features is shown in Fig. 7 while the proposed management units for the same are shown in Fig. 8. Similarly the primary cells, sub-cells and the management units have been delineated for the coast of West Bengal (Figs. 9 & 10).

There is increasing consensus among coastal practitioners and scientists that we should address the coastal erosion problem at its source. And that is an imbalance in the sediment budgets in the coastal zone. If sand is lost to deeper water, one should not be surprised that this can lead to erosion at the coast. Scientific knowledge of coastal processes is already well-developed. The next step is to generate monitoring and modeling that generate data on current and potential coastal behaviour.

Fig. 4: Primary cell delineation for the East and West Coast of India

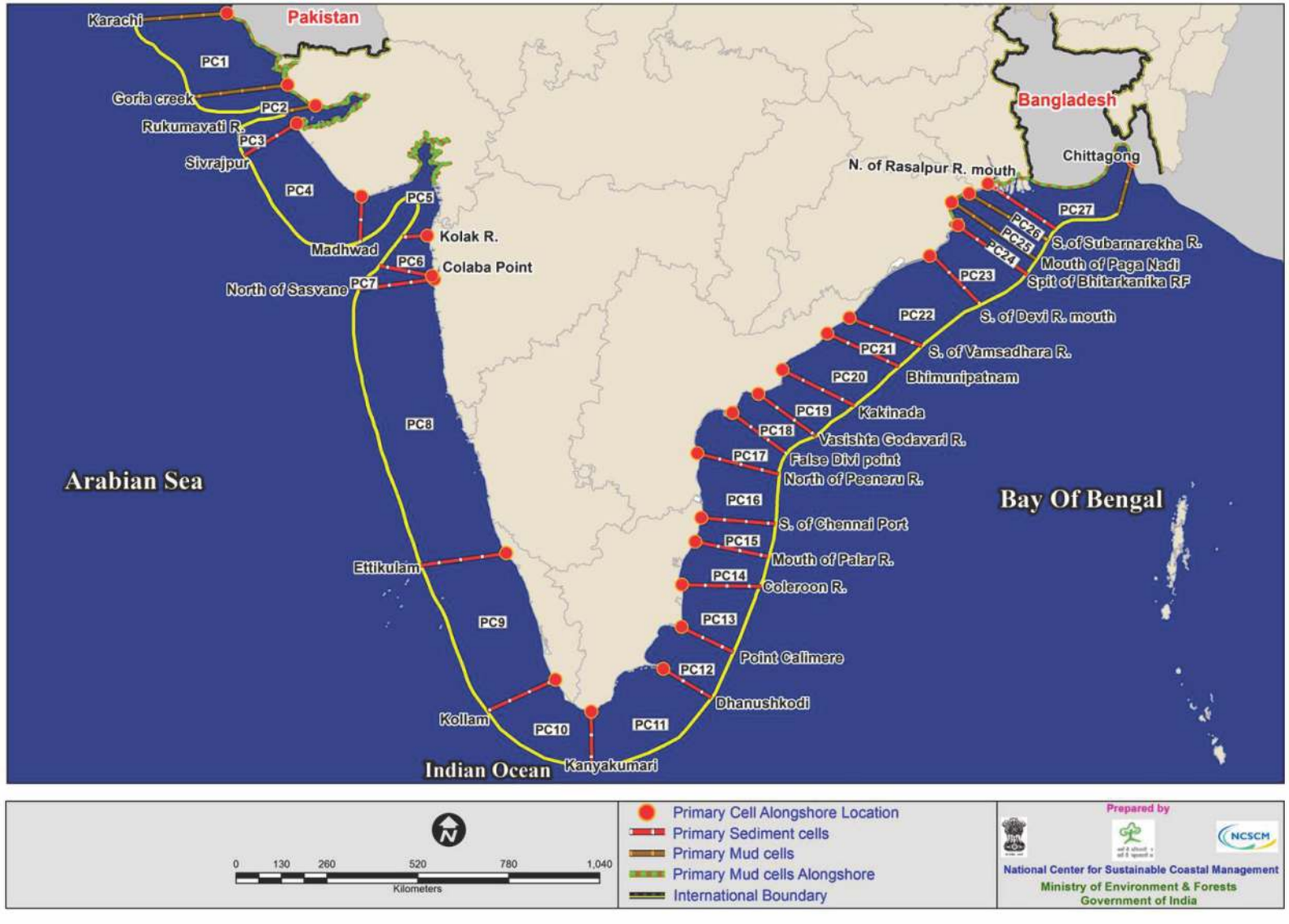


Fig 5: Primary cells that were identified within Odisha coast

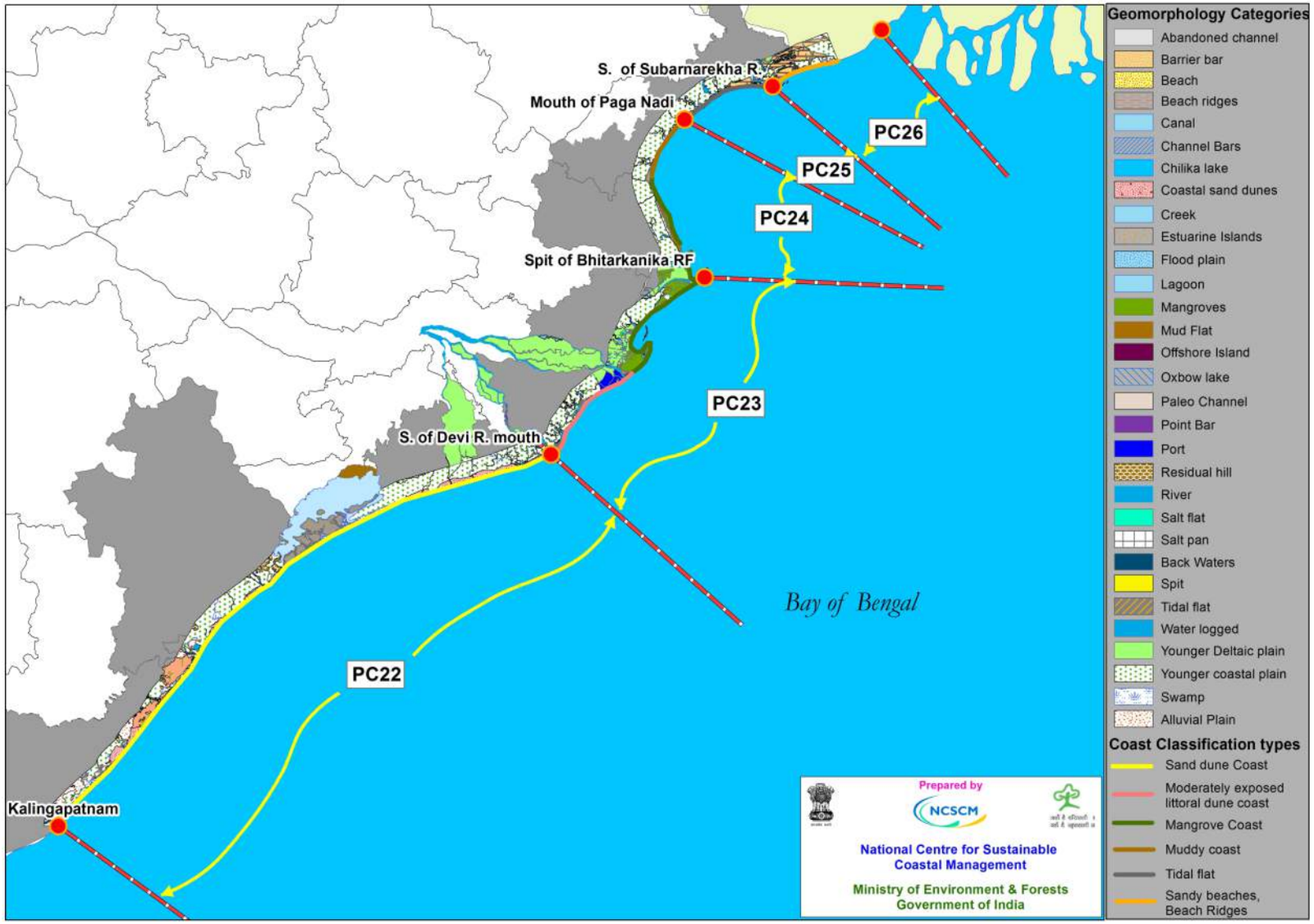


Fig. 6: Subcell demarcation within the Odisha coast with the criteria for subcell delineation by the expert committee.

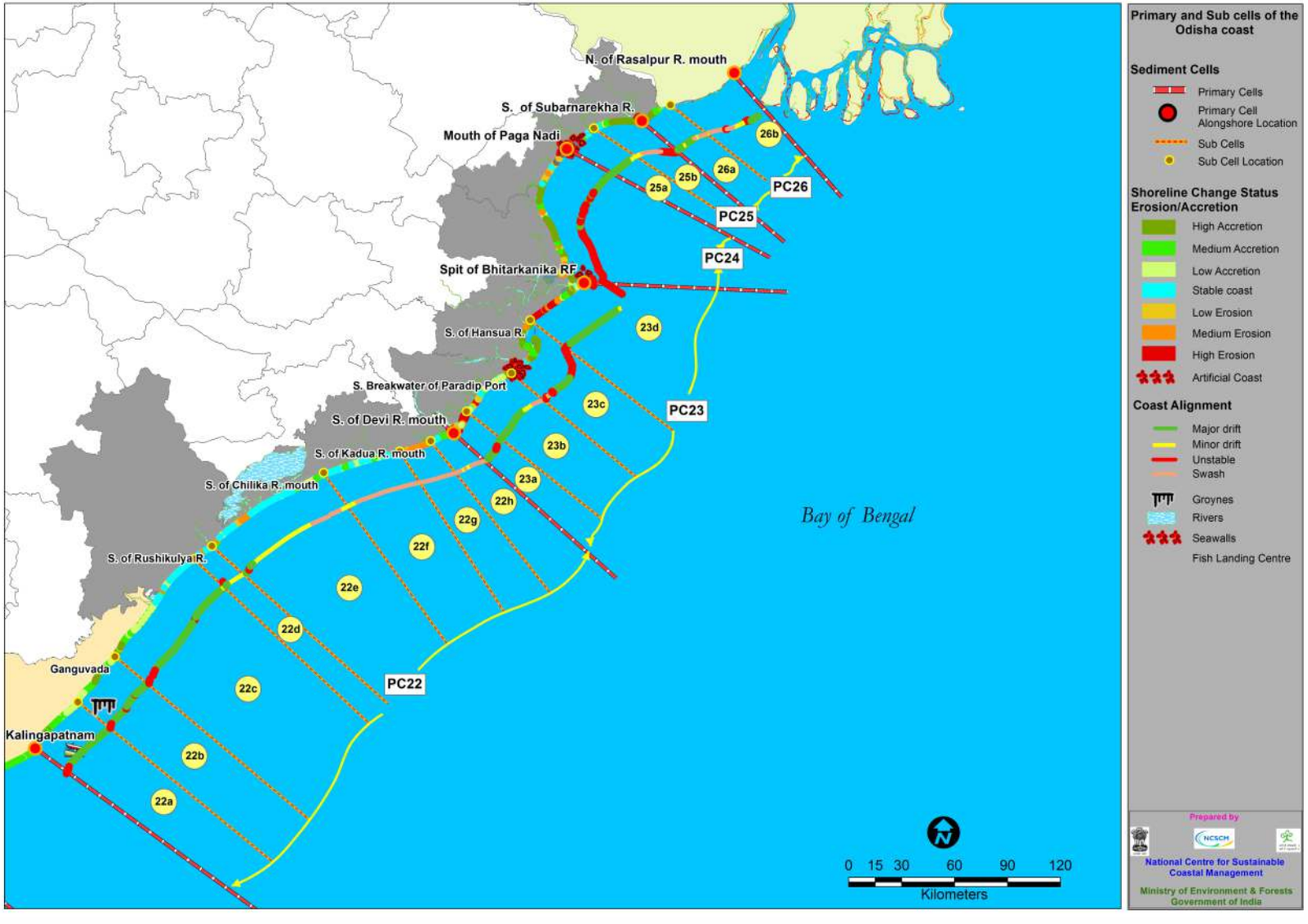


Fig 7 Subcell 22a of the Odisha coast along with the geomorphology features

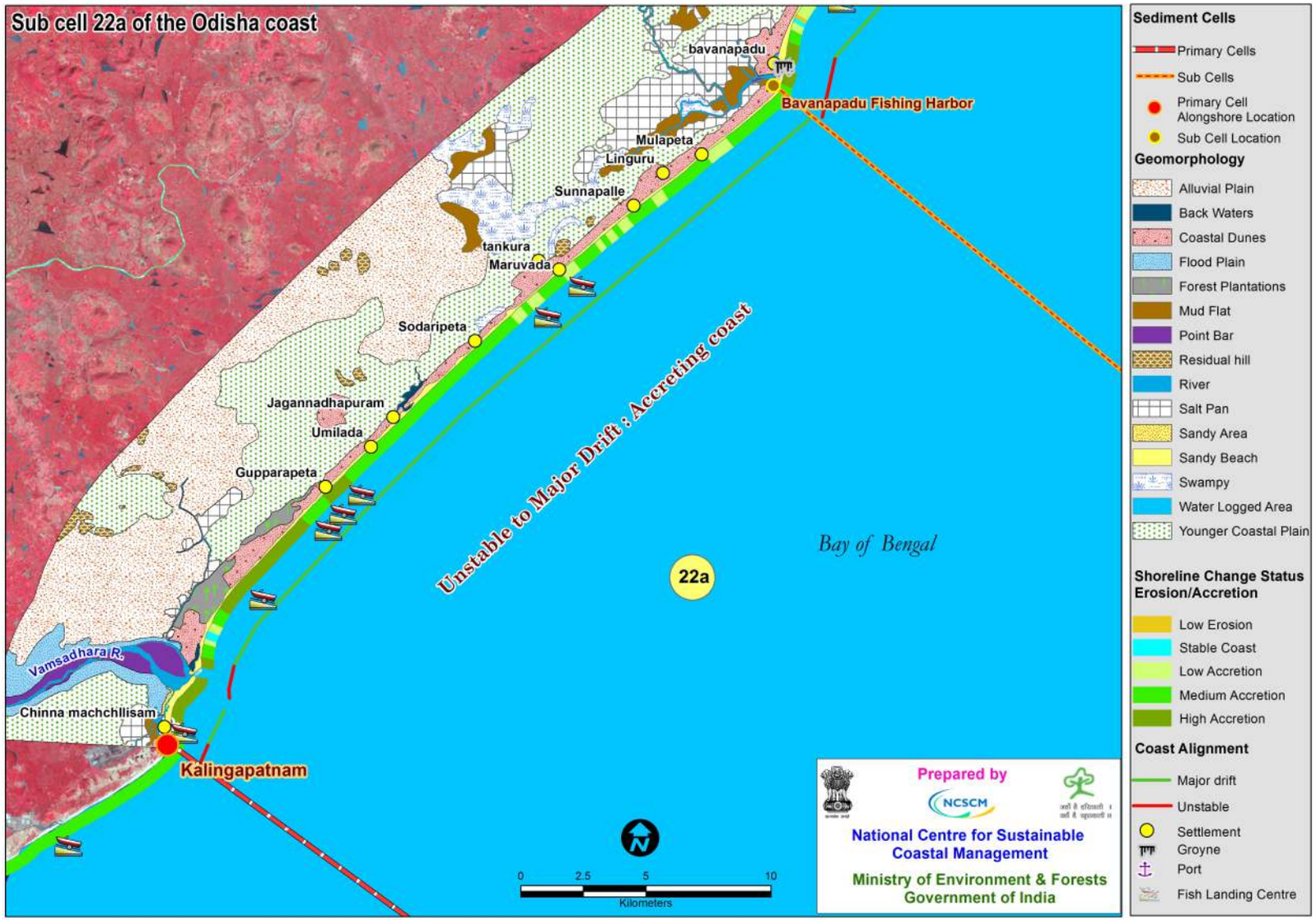


Fig 8. Management units for the subcell 22a of the Odisha coast

Fig 9: Primary cells that were identified for West Bengal coast

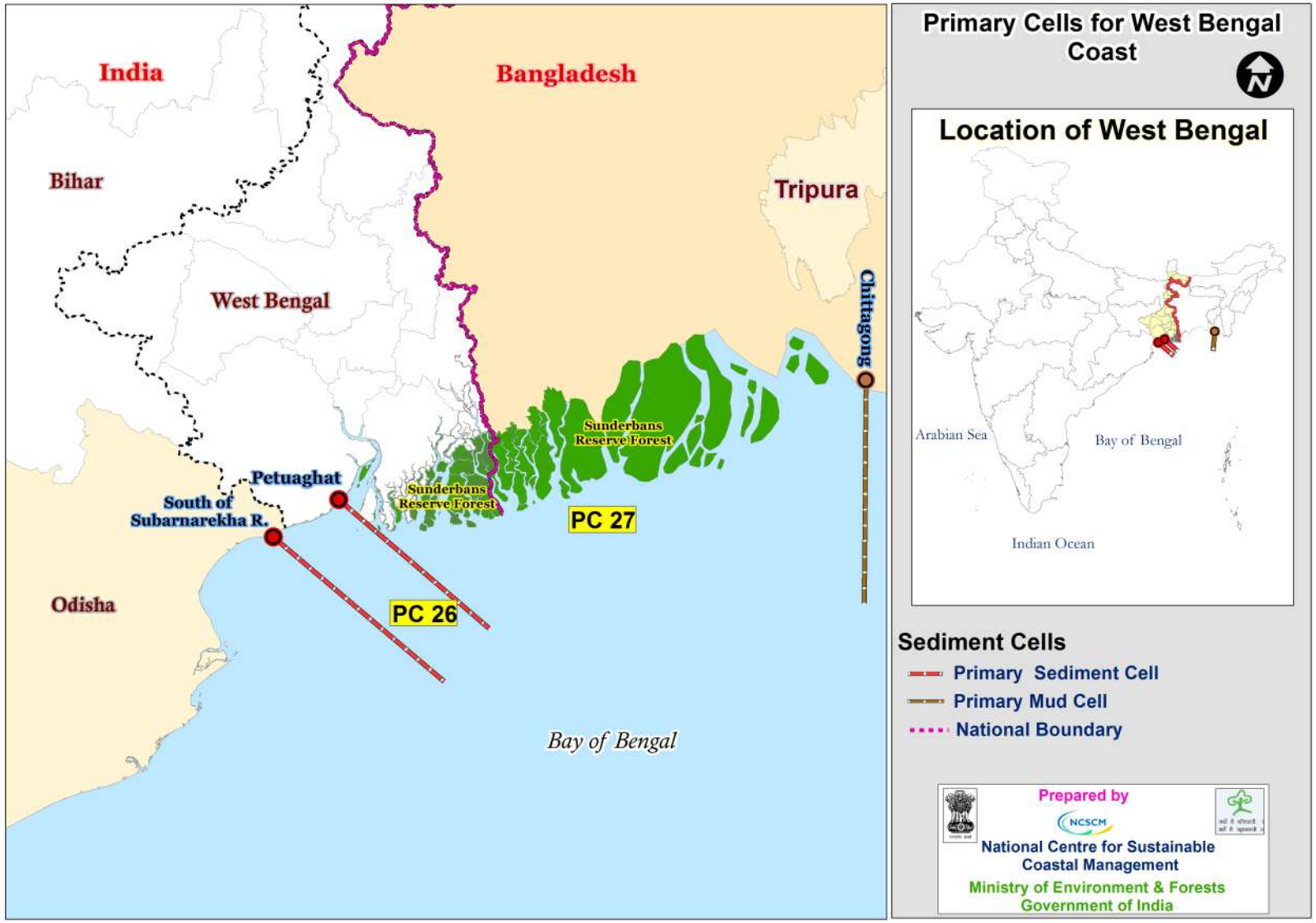


Fig. 10. Subcell demarcation for the West Bengal coast

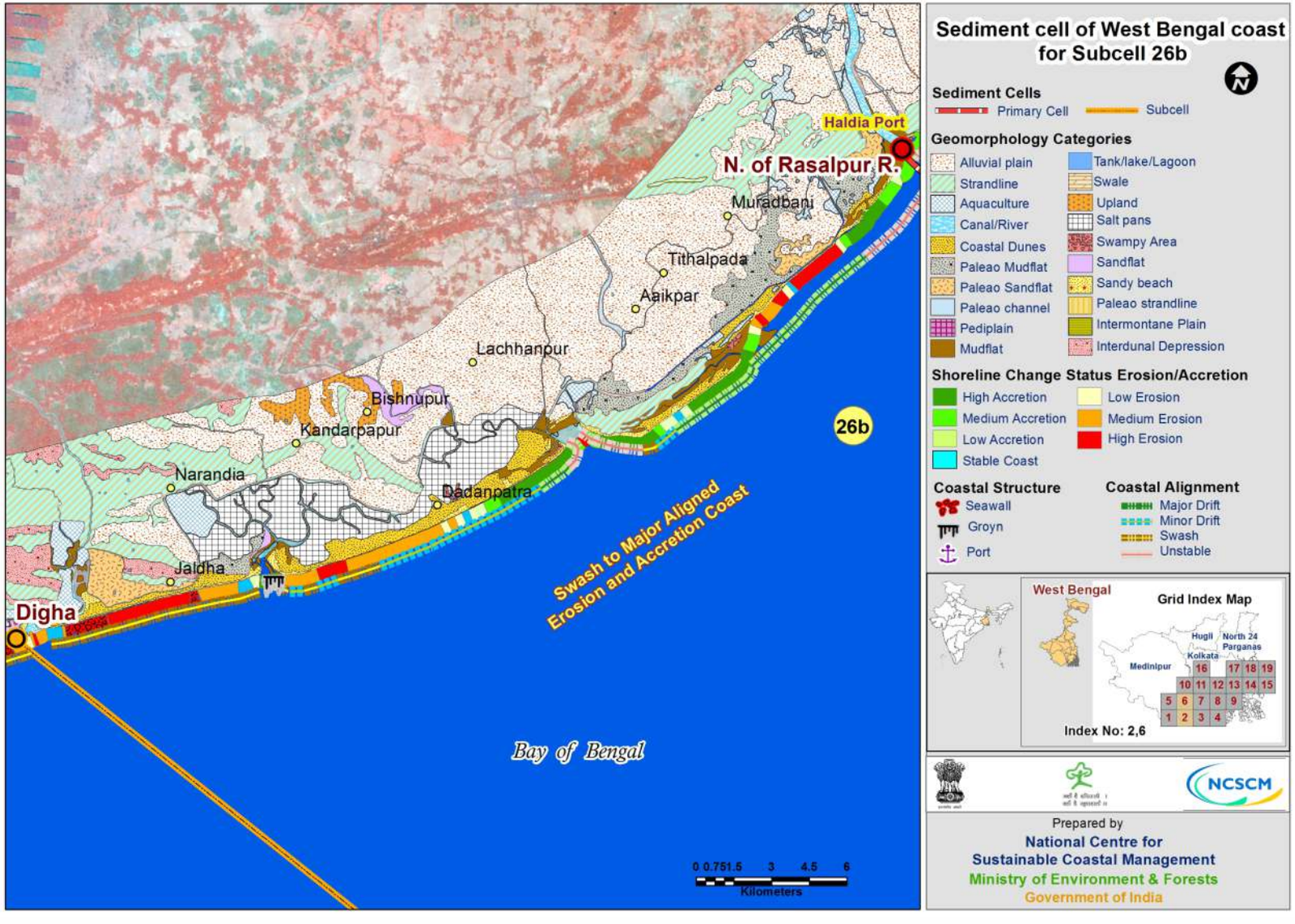


Fig 11: Subcell 27a of West Bengal coast along with the geomorphology features

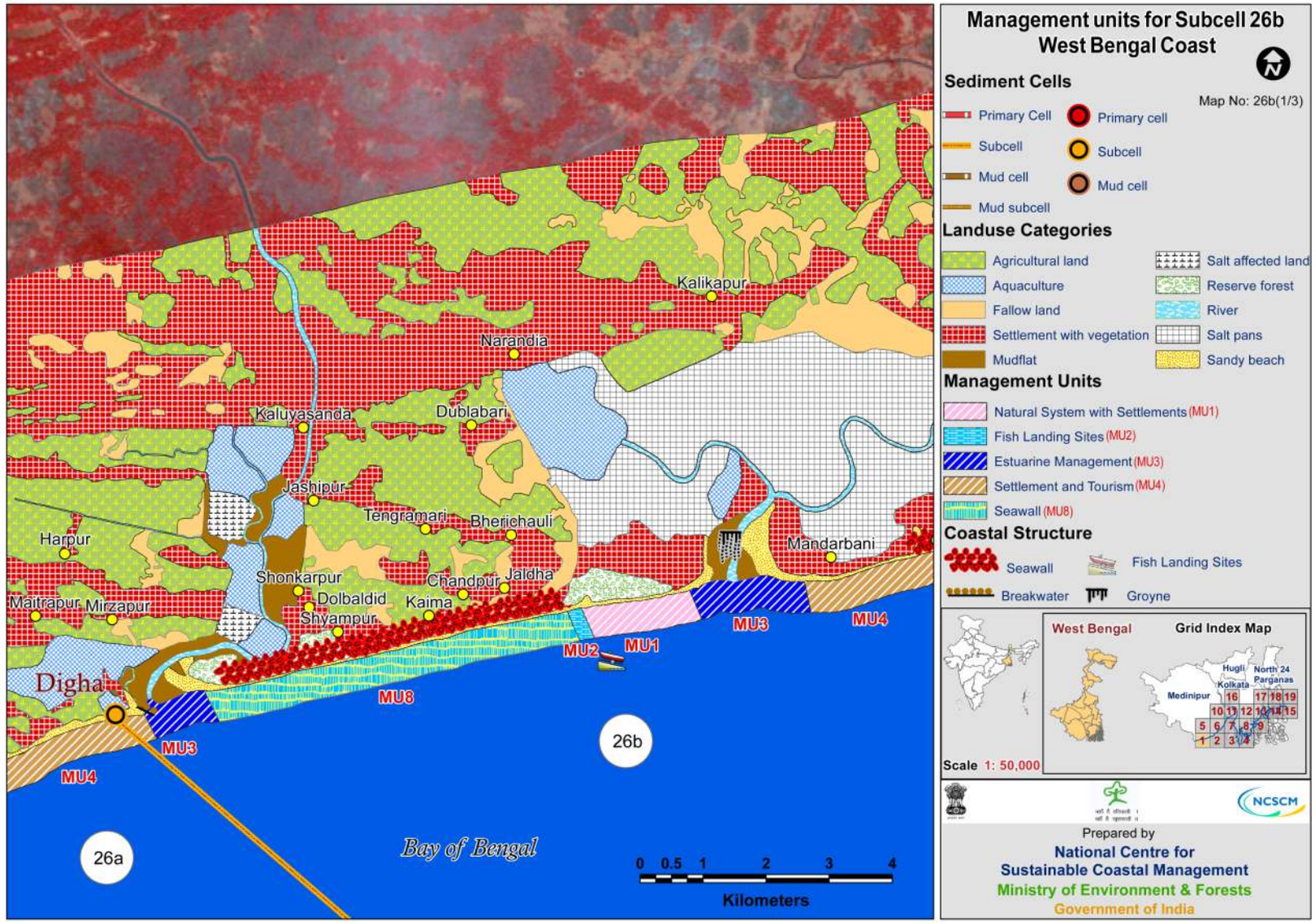
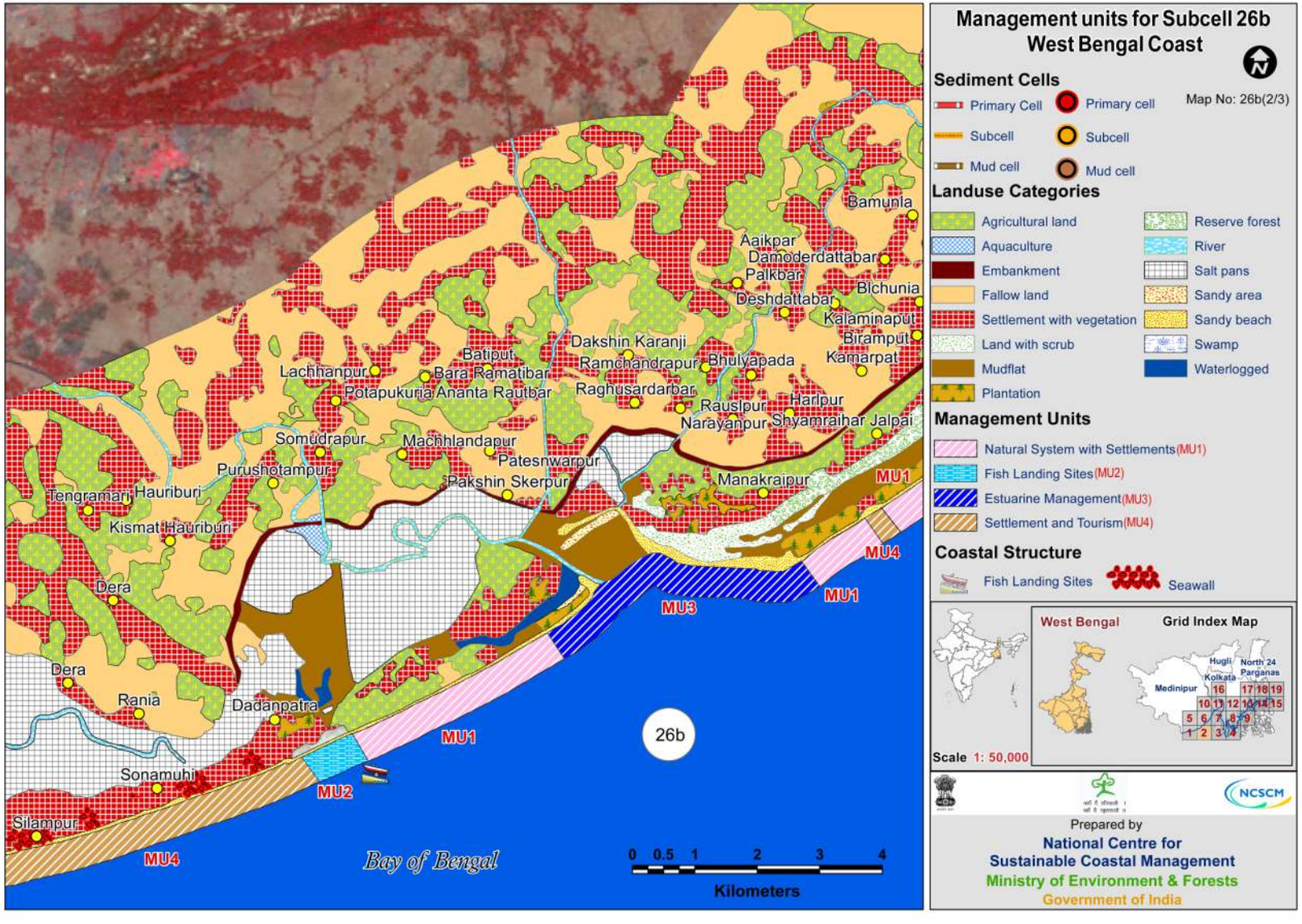


Fig 11: Subcell 27a of West Bengal coast along with the geomorphology features



Coastal Environmental Impact Assessment

Coastal Ecosystem Health Assessment & Report Card

Coastal lagoons have been recognized for their significance as productive ecosystems as well as for their important role in maintaining ecological balance. Chilika lagoon is the largest coastal lagoon in India and the second largest lagoon in the World. In 1981, Chilika Lagoon was designated the first Indian wetland of international importance under the Ramsar Convention, site number 229. A number of significant threats to the condition and sustainability of Chilika Lagoon include siltation, variable flushing with the ocean, physical and chemical pollution, tourism and over-fishing. The report card approach is used to enhance and support the management and restoration of any coastal ecosystem. In order to enhance the understanding and management of mentioned threats, Ecosystem Health Report Card (EHRC) for Chilika Lagoon is taken under consideration. EHRC is an effective means of tracking and reporting the health of a waterway at both seasonal and regional scales.

The Ecosystem Health Report Card (EHRC) for Chilika Lagoon being prepared by NCSCM will portray better changing conditions of the Chilika Lagoon. EHRC is unique in that it provides a geographically detailed and integrated approach to form numerical rankings of 4 reporting sectors of Chilika (Northern, Central, Southern and Outer Channel) on an annual basis. This approach compliments those focusing on assessment over longer time frames. The geographic detail provided in the report card reflects the complexity of Chilika Lagoon and its tributaries and provides information that can help guide and focus restoration efforts. Representation of report cards through color coding will help to communicate with the coastal communities or primary and secondary stakeholders. Visual communication will render the data more accessible and take forward the core message to the stakeholders in an easily understandable manner (Fig 1).

Fig. 1: Visually depicting the pressures in Chilika Lagoon and its effects

Source: IAN, University of Maryland, USA

Fourteen indicators were decided as appropriate for measuring the status of the identified values and the influence of the pressures. Indicators were grouped into three over-arching indices, as Water Quality Index (WQI), Fisheries Index (FI) and Biodiversity Index (BI) (Table 1). These indicators are used in combined manner to get an overarching Ecosystem Health Index (EHI), which represents the report card score.

Table 1: Chilika Lagoon Report Card indicators grouped by Index

Index	Indicators
Water Quality	Total nitrogen; Total phosphorus
	Water clarity (secchi)
	Dissolved oxygen
	Chlorophyll a
Fisheries	Total catch
	Commercial species diversity
	Size
Biodiversity	Bird species
	Dolphin abundance
	Seagrass biomass
	Seagrass distribution
	Benthic Index of Biological Integrity (B-IBI)
	Phytoplankton Index of Biological Integrity (P-IBI)

Threshold values assigned for each indicator are generally based on any one or a combination of the following:

- Regulatory guidelines (e.g. local or regional water quality guidelines);
- Biological limits (e.g. dissolved oxygen requirements for protection of an important species);
- Socio/economic requirements
  (e.g. minimal fish stocks determined to be required for sustainable fishery)
- Reference conditions
  (e.g. historical baseline or nearby system with conditions that would like to be matched)
- Professional judgment.

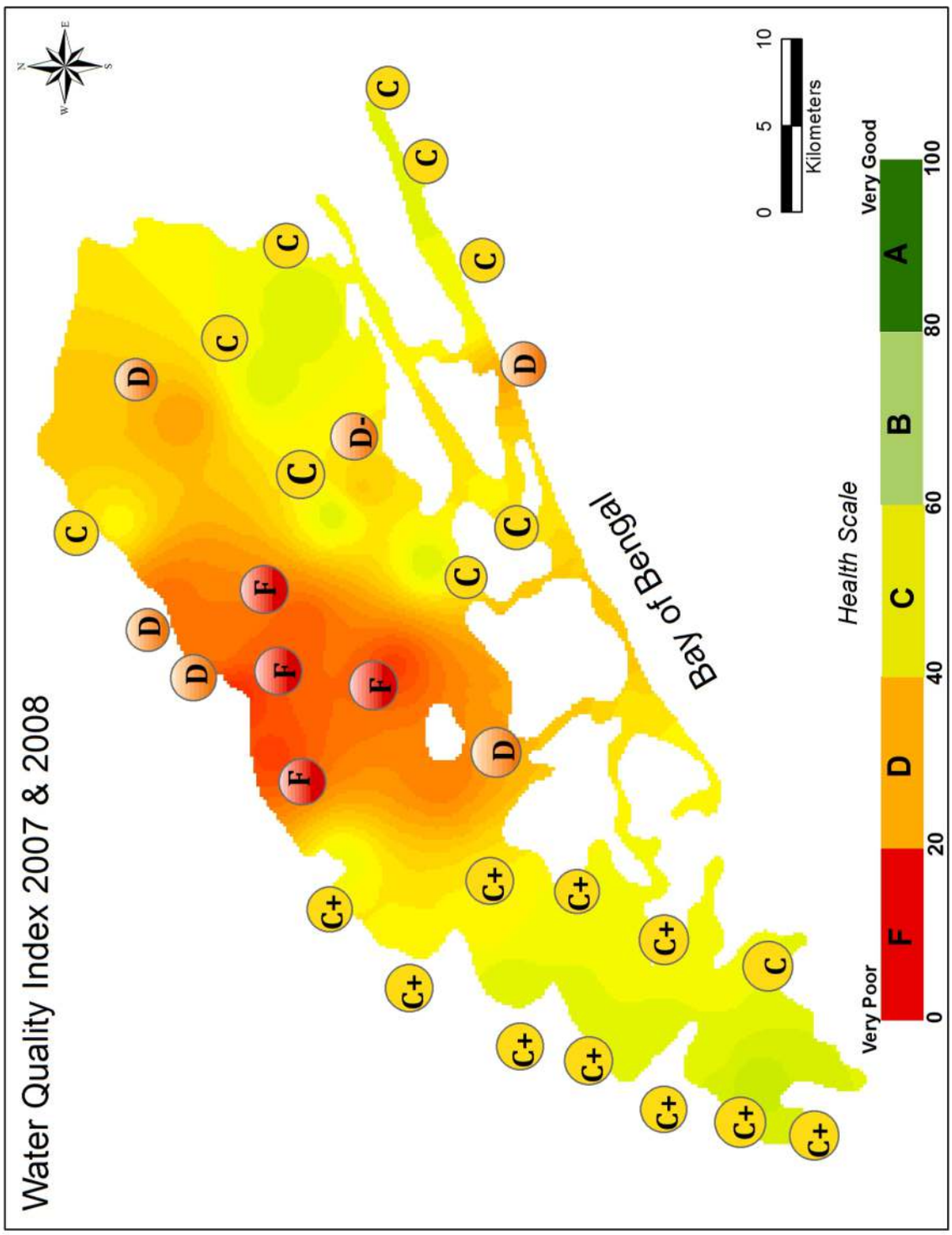
Finally, the EHI will be derived by averaging the WQI, FI and BI values for each sector. EHI values can be ranked in ascending order such as from the worst (dark red) to the best (green) (Fig 2). An ecosystem health report card for Chilika lake is shown in Fig 3.

Fig. 2: Ecosystem Health Index color code ranking

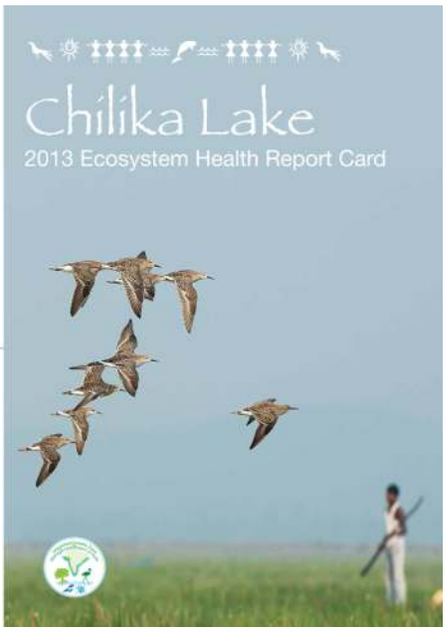
F	0 - 20
D	20- 40
C	40 - 60
B	60 - 80
A	80 - 100

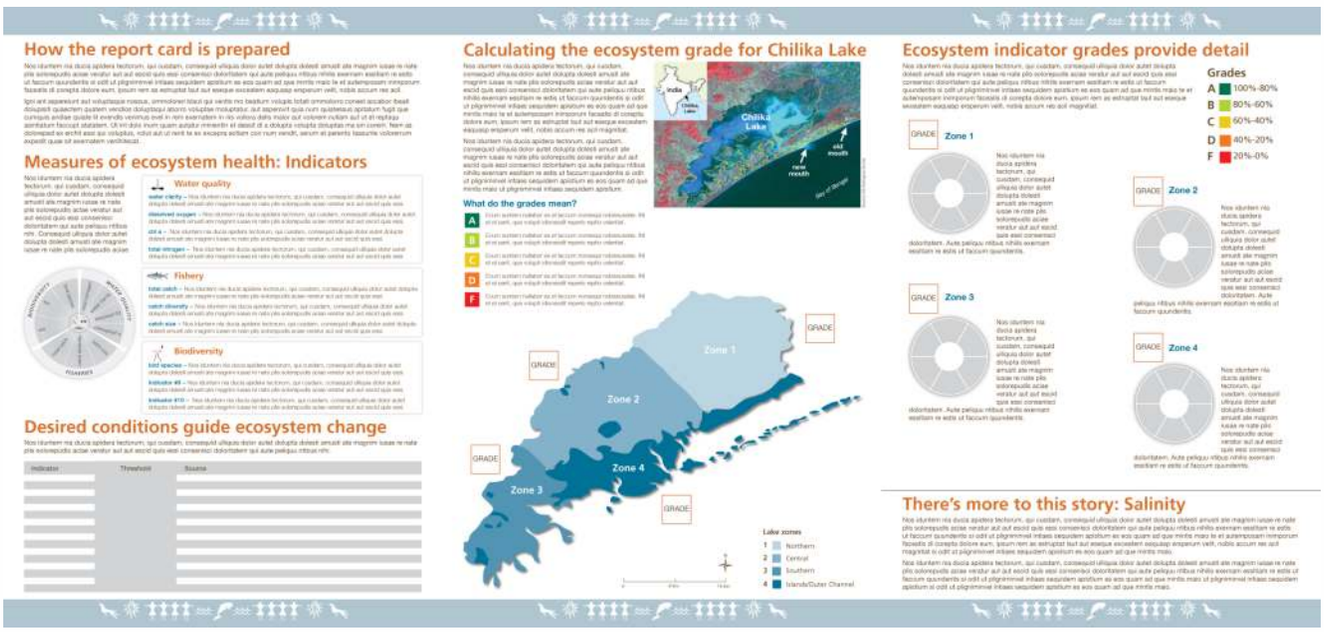
Fig. 3: Ecosystem Health Report Card (EHRC) for Chilika Lagoon

The report card is under development and a more complete assessment of Bay health expected in the future. The final report card will be prepared based on the available data on the Report Card scores.



Sample Report Card





Futuristic Research

Modeling Offshore Wind Energy Potentials for the Coast of India

It is expected that an important part of the future expansion of wind energy utilization will come from offshore sites. Wind is the one of the major sources of renewable energy available at least cost than the other energy options. Wind speed, in general is more in the offshore region compared to that observed onshore, making it a more reliable source for the production of electricity. For project planning and siting, especially for large projects, a reliable prediction of the wind resource is therefore crucial.

In this context, NCSCM has undertaken a preliminary study on feasibility of offshore winds along the east and west coast of India and Indian Islands (Andaman and Lakshadweep) using the Weather Research Forecasting Model (WRF) to simulate the offshore wind fields (Fig.1) The offshore wind speed was measured at different levels varying between 50 and 100 m above mean sea level.

As a preliminary study, the model has been simulated during the annual year 2012, but here we reported the methodology and results during July, 2012.The complete initial assessment of offshore wind energy is reported and identified the potentials in Exclusive Economic Zone (EEZ) (Fig. 2). The wind speed has been mapped at 50 m, 100 m, and 200 m depths (Fig.3) and the potential are identified and marked in EEZ. Bird migratory routes through India is represented in Fig. 4

Fig.1: Domain configuration of WRF Model

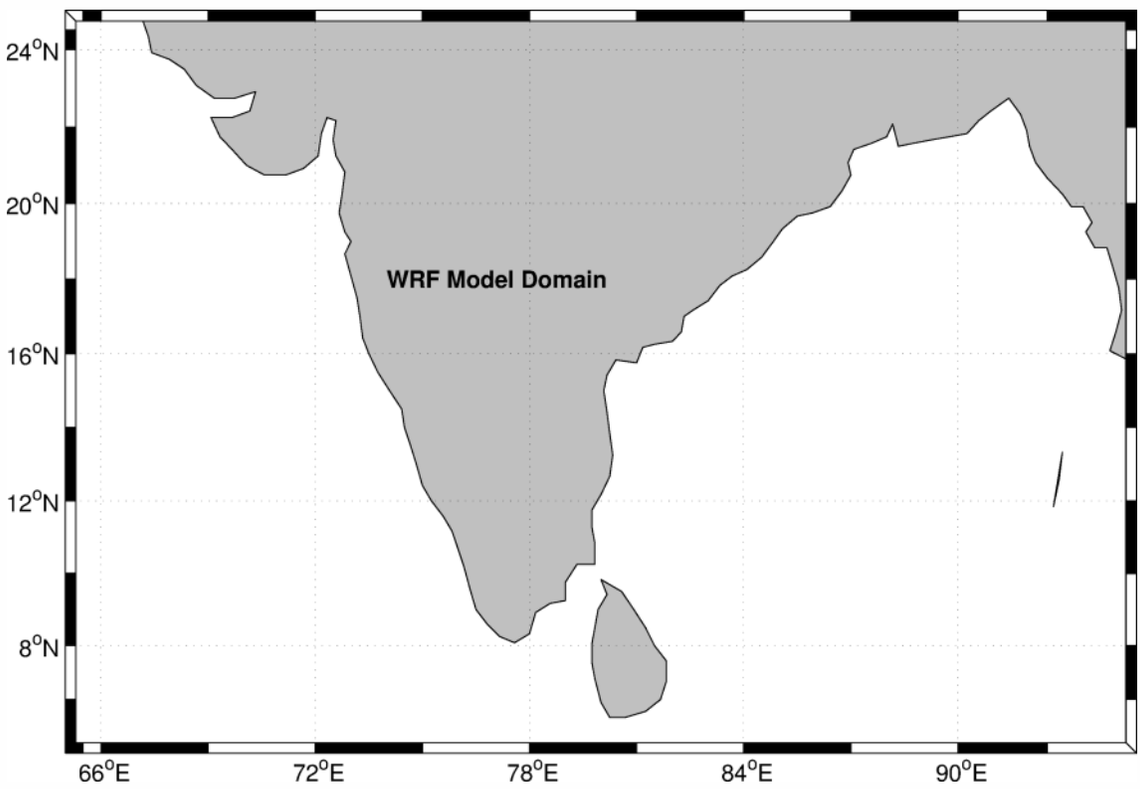


Fig.2: Initial assessment of offshore wind energy potentials in Exclusive Economic Zone (EEZ) during July, 2012

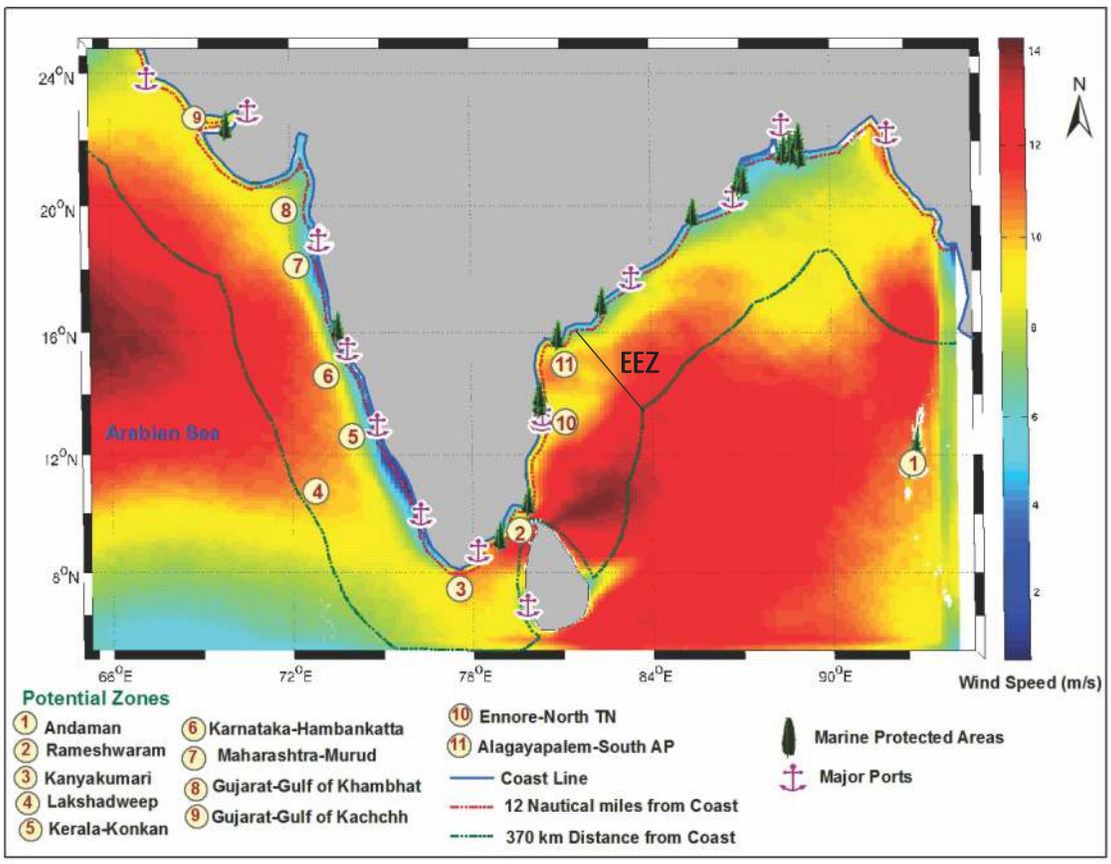


Table-1 Wind speed of potentials at different depths along the Indian coast and Islands

Wind Speed (m/s) at Different Depths			
Potential Zones	50m	100m	200m
	Wind Speed(m/sec)		
Andaman Island	12.50	12.75	12.75
Rameshwaram	12.75	12.00	12.00
Kanyakumari	12.30	11.00	10.00
Lakshadweep	11.00	12.00	12.00
Kerala-Konkan	4.50	9.00	8.00
Karnataka-Hambankatta	5.00	9.80	10.00
Maharashtra-Murud	5.00	11.00	12.00
Gujarat-Gulf of Kambhat	9.00	9.50	11.00
Gujarat-Gulf of Kachchh	9.80	9.00	10.00
Ennore -North TN	9.00	8.50	8.50
Alagayapalem-South Ap	9.20	8.90	12.50

Fig. 3: Mapping of offshore wind speed (m/s) and the marking of potentials around the Indian subcontinent, Coastal Andaman and Lakshadweep at the depth of (a) 50 m (b) 100 m and (c) 200 m.

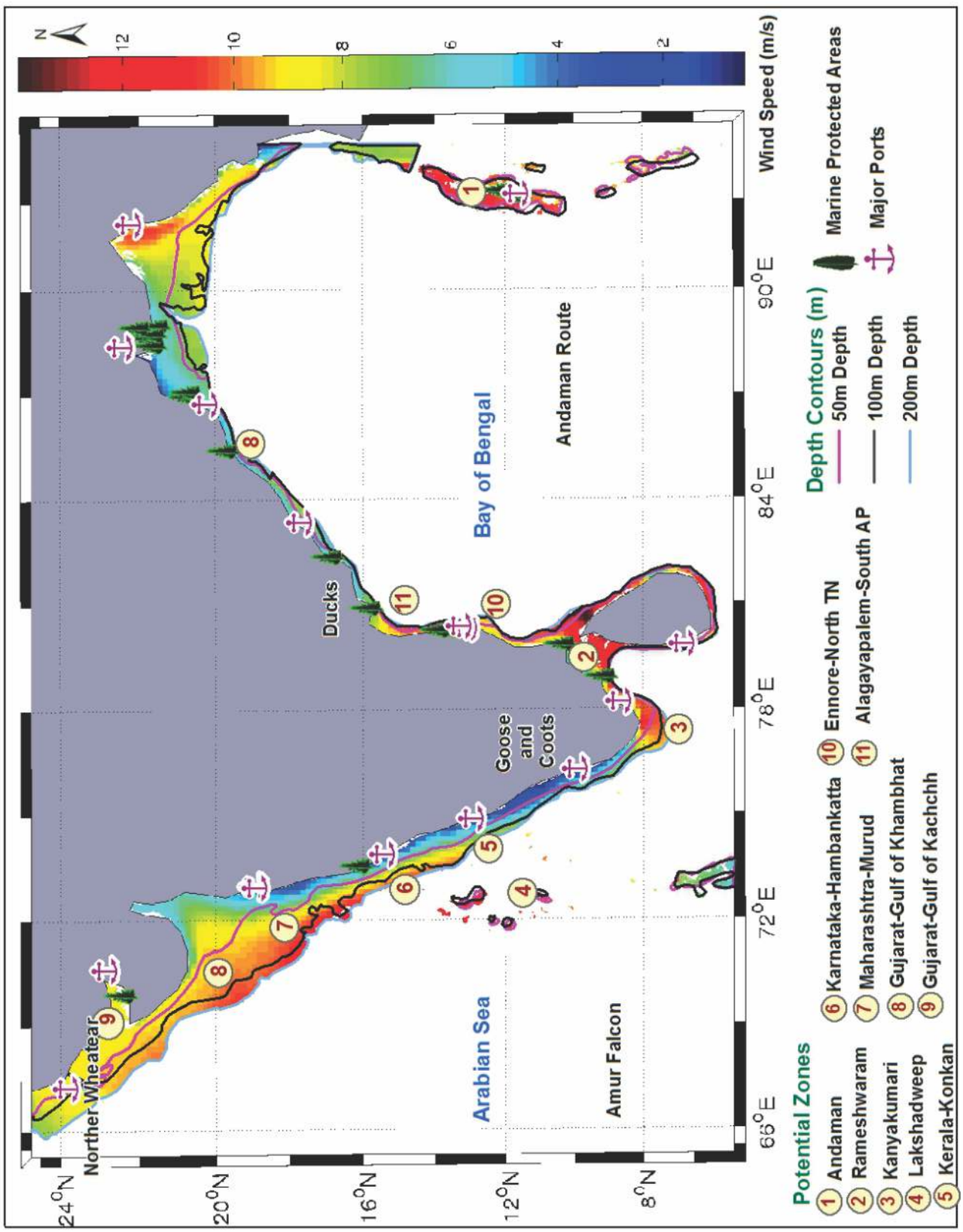
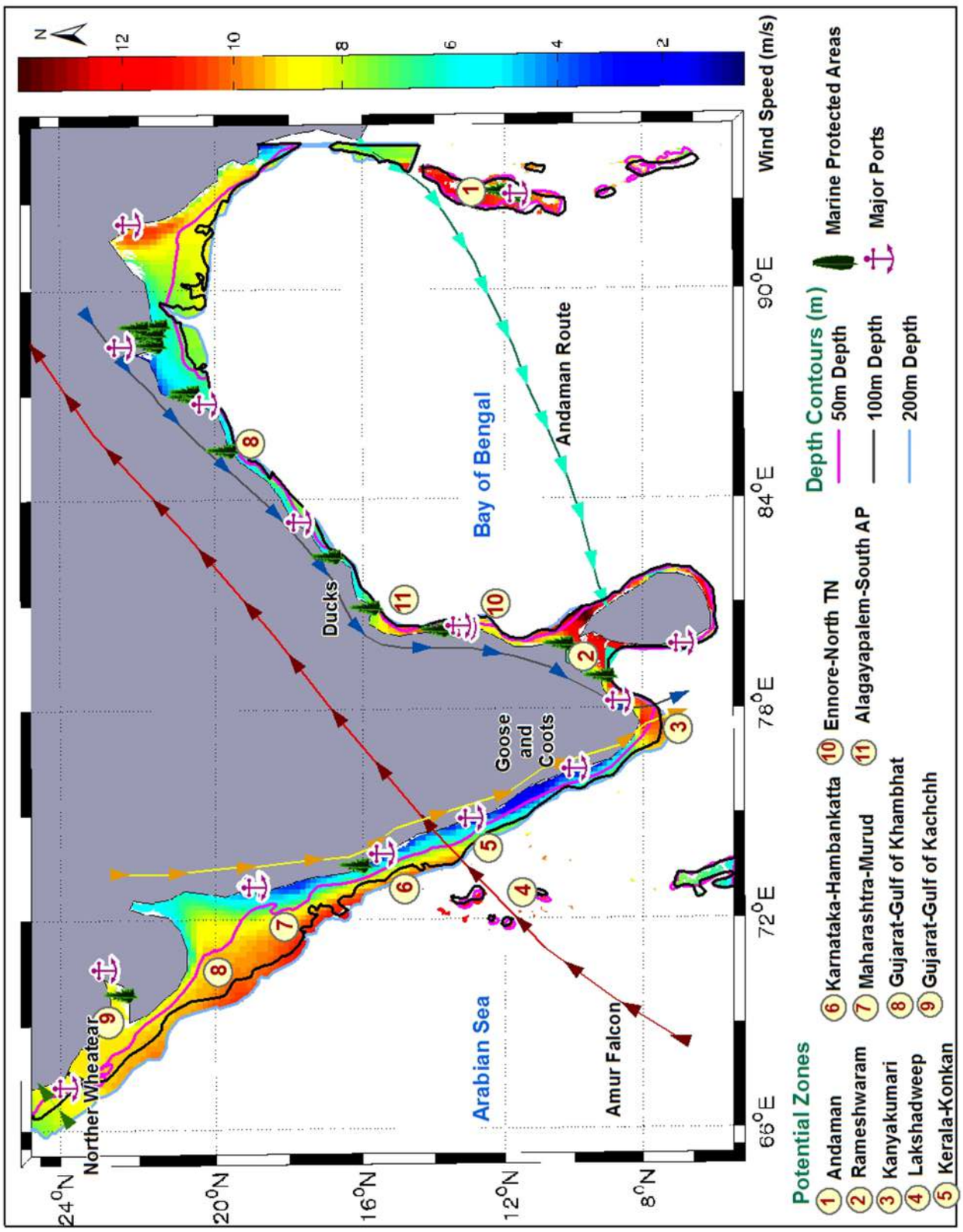


Fig. 4: Bird migratory routes through India



Greenhouse Gas Inventory in Coastal Ecosystem

Several studies showed that coastal ecosystems (mainly mangroves, estuaries, lagoons, salt marsh waters and coral reefs) are the important sources of climatically active greenhouse gases to the atmosphere, impacting regional or even global tropospheric budgets (Borges et al 2003b; Upstill-Goddard 2006). These ecosystems receive massive inputs of organic matter, which is decomposed in the coastal ocean and releases CO_2 (Borges 2005). However, besides the organic matter, there are also nutrients coming from the land, enhancing the primary production and thus causing an uptake of CO_2, which possibly could result in a net CO_2 influx at the coastal ocean. In general, coastal ecosystems are CO_2- supersaturated as a result of the respiration of the riverine OC input (Chen 2004). The overall source of CO_2 from near-shore ecosystems has been evaluated to ~0.50 Pg C y^{-1}, mainly related to the emission of CO_2 to the atmosphere from estuaries (~0.36 Pg C y^{-1}) (Chen and Borges 2009). Borges et al (2003a) reported oversaturation of CO_2 in different mangrove forest surrounding waters, suggesting that this surface water be a significant source of CO_2 to the atmosphere, though the entire ecosystems (sediment, water and vegetation) are probably sinks. The direction and magnitude of air-water CO_2 exchanges strongly depend on the type of ecosystem at the coast (Borges et al 2005).

Hence, the assessment of greenhouse gases (CO_2, CH_4, N_2O) emitted to and removed from the atmosphere is high on the international scientific agendas. Growing international concern and cooperation regarding the climate change problem have increased the need for inventorisation of greenhouse gas (GHG) emissions. However, in India very sparse data is available in terms of GHG emission from Indian coastal ecosystems.

Hence, our current research objective is to create a national level GHG inventory from Indian coastal ecosystems. The work plan for this research includes:

- Ecosystem based GHG inventorisation
- Understanding the uncertainties related to GHG inventory
- Find out the gap of research

For this, a review of GHG research from the entire country has been undertaken (Table 1, 2 & 3). Greenhouse gas emission data are mostly available from mangroves (Figure 1, 2 & 3), estuaries (Figure 4, 5 & 6), and lagoons (Figure 7, 8 & 9) whereas, emissions from seagrass and coral reef ecosystems are totally missing. These estimations are based on direct or indirect methods. The major uncertainty associated with the Indian GHG inventory is due to considerable differences in the results obtained from same ecosystem. This could be attributed to the difference in respective approaches, and different background status (like: seasonal effect, tidal effect, etc.).

Table 1a: Greenhouse gas emission inventories for Mangroves : WATER - AIR FLUX

WATER - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O		
				Method	Flux Mol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference
1	SUNDARBANS	WEST BENGAL	2123	Indirect Flux (Borges et al 2004)	1.10	Neetha V. 2008 (Unpublished Thesis)	Indirect Flux (Borges et al 2004)	0.027	Neetha V. 2008 (Unpublished Thesis)	No available Data		
				Indirect Flux (Borges et al 2004)	20.70	Ghosh et al 1983; Borges et al 2003						
				Indirect Flux (Borges et al 2004)	30.66	Kakolee Banerjee 2012 (Unpublished Thesis)	Indirect Flux (Wanninitho f 1992)	29.2	Kakolee Banerjee 2012 (Unpublished Thesis)			
				Direct Flux (Floating Chamber)	20.91		Direct Flux (Floating Chamber)	16.79				
				Indirect Flux (Micrometeor ological Method)	0.11	Biswas et al 2004	Indirect Flux (Micrometeor ological Method)	0.7 - 49.1	Biswas et al 2004			
				Indirect Flux (Micrometeor ological Method)	(-)2358 - 24655	Mukhopadhyay et al 2002	Indirect Flux (Micrometeor ological Method)	(-) 8928.6 - 17502.5	Mukhopadhyay et al 2002			
				No available Data			Indirect Flux (Micrometeor ological Method)	2.6 to 20.7	Biswas et al 2007			
2	PICHAVARAM	TAMIL NADU	12	Indirect Flux (Borges et al 2004)	27.01	Neetha V. 2008 (Unpublished Thesis)	Indirect Flux Calc (Borges et al 2004)	0.19	Neetha V. 2008 (Unpublished Thesis)	Direct Flux Calc (Floating Chamber)	11.4	Purvaja et al 2008
							Direct Flux Calc (Floating Chamber)	92.0 - 160.3	Senthilkumar B. 2007(Unpublished Thesis)	Direct Flux Calc (Floating Chamber)	3.7 - 11.4	Senthilkumar B. 2007 (Unpublished Thesis)
3	MUTHUPET		18.55	No available Data						Direct Flux Calc (Floating Chamber)	1.1 - 1.3	Purvaja et al 2008
4		ANDAMAN & NICOBAR	966	Indirect Flux Calc (Borges et al 2004)	33.58	Neetha V. 2008 (Unpublished Thesis)	Indirect Flux Calc (Borges et al 2004)	0.22	Neetha V. 2008 (Unpublished Thesis)	No available Data		
				Direct Flux Calc (Floating Chamber)	27.38		Direct Flux Calc (Floating Chamber)	0.20				
							Indirect Flux Calc (Clark et al 1995)	201.4 - 210.2	Barnes et al 2006	Indirect Flux Calc (Clark et al 1995)	2.0 - 2.1	Barnes et al 2006
							Direct Flux Calc (Floating Chamber)	302.2		Direct Flux Calc (Floating Chamber)	11.4	
										Indirect Flux Calc (Air-Sea gas exchange model)	2.0 - 2.1	Purvaja et al 2008
										Direct Flux Calc (Floating Chamber)	10.5	

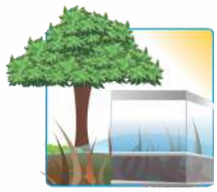


Table 1b: Greenhouse gas emission inventories for Mangroves: SEDIMENT - WATER - AIR FLUX

SEDIMENT - WATER - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O		
				Method	Flux Mol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference
1	SUNDARBANS	WEST BENGAL	2123	No available Data			Static chambers	280.3	Ramesh et al 2007	Static Chamber	0.2	Purvaja et al 2008
							Static chambers	4734 - 19173	Biswas et al 2007			
2	BHITARKANIKA	ODISHA	215	No available Data			Chamber method; flux through pneumatophores	50 - 1768	Chauhan et al 2008	Static Chamber	1.8 - 41.4	Chauhan et al 2008
3	CORINGA	ANDHRA PRADESH	465	No available Data			Chamber method	2008 - 8098	Krupadam et al. 2007			
4	ICHAVARAM	TAMIL NADU	12	No available Data			Close Chamber Technique	14585	Purvaja and Ramesh, 2000	Static Chamber	3.5 - 3.8	Purvaja et al 2008
							Static chambers	184 - 586.9	Purvaja et al 2004	Static Chamber	9.9 - 14.0	Senthilkumar B. 2007 (Unpublished Thesis)
							Close Chamber Technique	341.6 - 543.1	Senthilkumar B. 2007(Unpublished Thesis)			
5	MUTHUPET		18.55				Static chambers	551.9	Ramesh et al 2007	Static Chamber	1.4 - 2.6	Purvaja et al 2008
				No available Data			Chamber method; flux through pneumatophores	431 - 855	Krithika et al. 2008	Static Chamber	13.1	Barnes et al 2006
										Static Chamber	3.6 - 6.7	Krithika et al. 2008
6	ADYAR ESTUARY MANGROVE		0.48	No available Data			Close Chamber Technique	30353	Purvaja and Ramesh, 2000	No available Data		
7	ENNORE CREEK		0.7				Close Chamber Technique	9894				
8		ANDAMAN & NICOBAR	966	No available Data			Static chambers	155.9 - 252.3	Barnes et al 2006	Static chambers	1.1 - 1.8	Barnes et al 2006

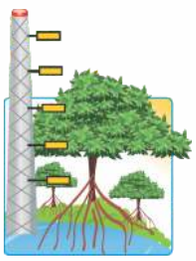


Table 1c: Greenhouse gas emission inventories for Mangroves : CANOPY - AIR FLUX

CANOPY - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O		
				Method	Flux Mol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference
1	SUNDARBAN	WEST BENGAL	2123	Indirect Flux Calc (Micrometeorological Method)	(-)157.1 - 423.6	Chanda et al 2013	No available Data					
				Indirect Flux Calc (Micrometeorological Method)	-400.7	Ganguly et al 2008	Indirect Flux Calc (Micrometeorological Method)	2700 - 14369	Ganguly et al 2008	No available Data		
				Indirect Flux Calc (Micrometeorological Method)	0.0004	Mukhopadhyay et al 2001		0.0162	Mukhopadhyay et al 2001			
2	PICHAVARAM	TAMIL NADU	12	No available Data			Chamber, Flux through Pneumatophore	168.8 - 1453.2	Purvaja et al 2004	No available Data		

Table 2: Greenhouse gas emission inventories for Estuaries : WATER - AIR FLUX

WATER - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O		
				Method	Flux Mol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference
1	HOOGHLY	WEST BENGAL	1380	Indirect Flux (Micrometeorological Method)	8.15	Mukhopadhyay et al 2002	Indirect Flux (Micrometeorological Method)	0.32 – 54.24	Biswas et al 2007	No Data Available		
				Indirect Flux (Borges et al 2004)	3.65 – 834.8	Kakolee Banerjee 2012 (Unpublished Thesis)	Indirect Flux (Borges et al 2004)	(-)7.3 – 770	Kakolee Banerjee 2012 (Unpublished Thesis)	No Data Available		
				Direct Flux (Floating Chamber)	16.8 – 216		Direct Flux (Floating Chamber)	13.5 – 249.7				
				Indirect Flux (Borges et al 2004)	12.8	Neetha V. 2008 (Unpublished thesis)	Indirect Flux (Borges et al 2004)	8.39	Neetha V. 2008 (Unpublished Thesis)			
2	MAHANADI	ODISHA	13.56	Indirect Flux	1.12	Sarma et al 2012	No Data Available			No Data Available		
			13.56	Indirect Flux	2.60	Ganguly et al 2010						
3	RUSHIKULYA		12.57	Indirect Flux	(-)0.0073	Sarma et al 2012						
4	GAUTAMI-GODAVARI	ANDHRA PRADESH	330	Indirect Flux	22.14	Sarma et al 2012	No Data Available			No Data Available		
				Indirect Flux	7.99	Bouillon et al 2003						
				Indirect Flux	52.6	Sarma et al 2011						
5	KRISHNA		36.5	Indirect Flux	2.49	Sarma et al 2012						
6	ENNORE	TAMIL NADU	2.25				Direct Flux (Floating Chamber)	2748	Purvaja and Ramesh 2001	No Data Available		
7	ADYAR		5	Indirect Flux (Borges et al 2004)	23.7	Neetha V. 2008 (Unpublished Thesis)	Indirect Flux (Borges et al 2004)	3.10	Neetha V. 2008 (Unpublished Thesis)			
				Direct Flux (Floating Chamber)	91.6		Direct Flux (Floating Chamber)	13.99				
							Direct Flux (Floating Chamber)	11249	Purvaja and Ramesh 2001			
							Indirect Flux	2.85×10^5	Rajkumar et al 2008	Indirect Flux	30×10^6	Rajkumar et al 2008
8	VELLAR		20.63	Indirect Flux	6.21	Sarma et al 2012				No Data Available		
9	CAUVERY		20.63	Indirect Flux	0.81	Sarma et al 2012						
10	ASHTAMUDI	KERALA	32				Indirect Flux	416.1	Zachariah and Johny 2008	No Data Available		
11	MANDOVI	GOA	27.68	Indirect Flux	6.99	Sarma et al 2012				No Data Available		
				Indirect Flux	(-)0.80 - 59.1	Sarma et al 2001						
12	ZUARI		14.62	Indirect Flux	2.35	Sarma et al 2012						
13	TAPTI	GUJARAT	41.04	Indirect Flux	132.3	Sarma et al 2012	Indirect Flux	1082 nmol l^{-1}	Nimal Kumar 2010	No Data Available		
14	NARMADA		115.5	Indirect Flux	3.20	Sarma et al 2012						

Table 3a: Greenhouse gas emission inventories for Lagoons : WATER - AIR FLUX

WATER - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O		
				Method	Flux Mol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference
1	CHILIKA	ODISHA	906 - 1165	Indirect Cai and Wang 1998	25	Gupta et al 2008	No available data			No available data		
				Indirect Cai and Wang 1998	31.2	Maduli et al 2012						
				Indirect Cai and Wang 1998	14.2 - 60.6	Ajay Kumar Ray 2010 (Unpublished Thesis)	Indirect Flux	1595	Ajay Kumar Ray 2010 (Unpublished Thesis)	Indirect	(-)0.95 - 17.05	Ajay Kumar Ray 2010 (Unpublished Thesis)
2	PULICAT	ANDHRA PRADESH	250 - 460	No available data			Indirect Flux	65.7	Shalini et al 2006	No available data		
3	VEMBANAD	KERALA	231	Indirect Cai and Wang 1998	55.1	Gupta et al 2009	No available data					
				Indirect Cai and Wang 1998	73.3	Paneer Selvam2013 (Unpublished Thesis)	Indirect Method	98.2	Paneer Selvam2013 (Unpublished Thesis)	No available data		

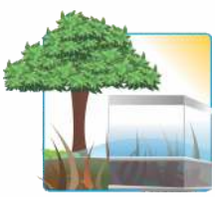


Table 3b: Greenhouse gas emission inventories for Lagoons : SEDIMENT - WATER - AIR FLUX

SEDIMENT - WATER - AIR FLUX

	Name	State	Area (Km^2)	CO_2			CH_4			N_2O			
				Method	Flux	Reference	Method	Flux mmol C m^{-2} yr^{-1}	Reference	Method	Range / Mean	Flux	Reference
1	CHILIKA	ODISHA	906 - 1165	No Available Data									
2	PULICAT	ANDHRA PRADESH	250 - 460	No Available Data			Direct Static Chamber	499	Shalini et al 2006	No Available Data			
3	VEMBANAD	KERALA	231	No Available Data			Direct Static Chamber	1854 - 153731	Verma et al 2002	No Available Data			

CO_2 Fluxes from Mangroves (mol C m^{-2} yr^{-1})

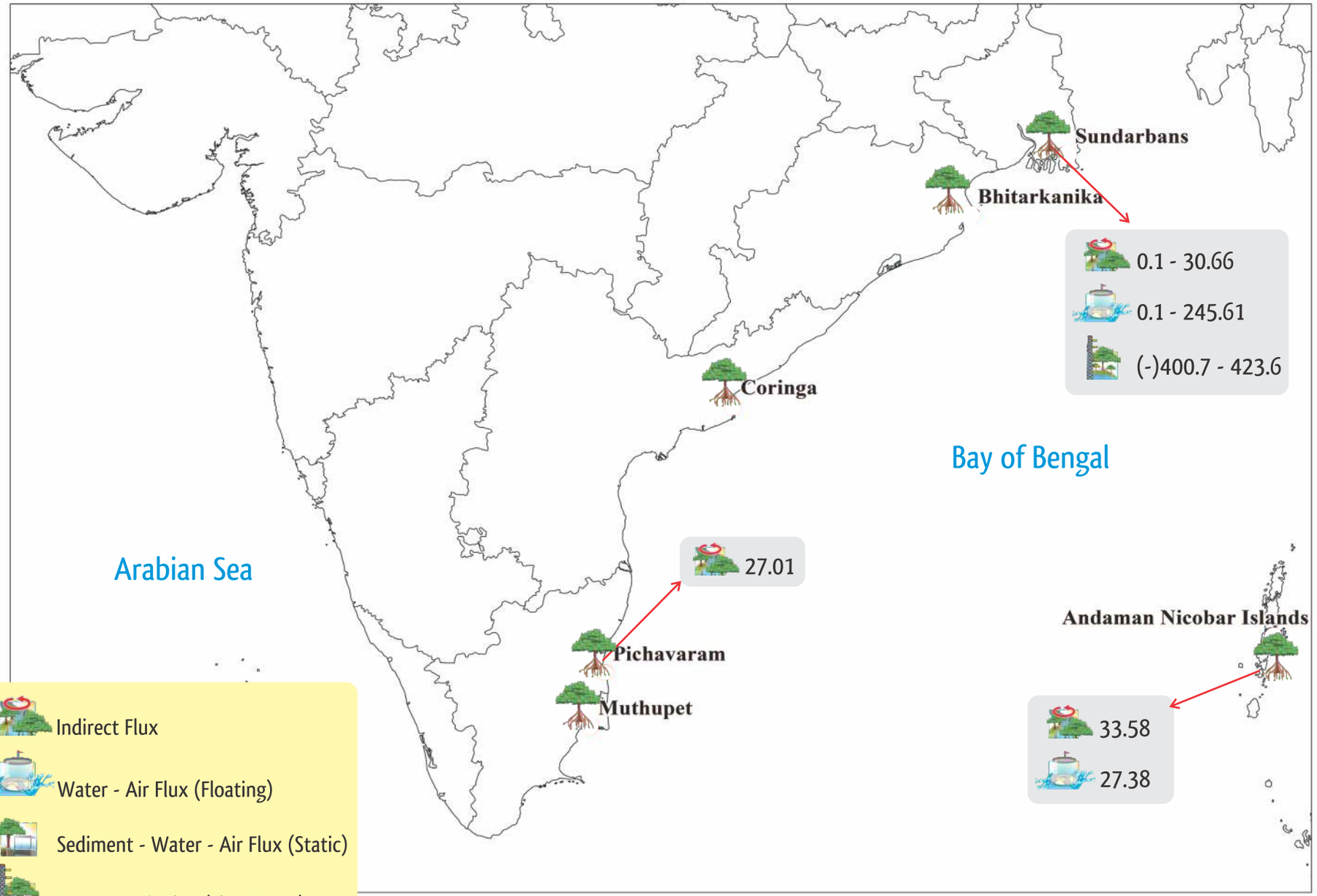


Fig. 1: CO_2 source-sink inventory from Indian Mangroves

CH_4 Fluxes from Mangroves (mmol C m^{-2} yr^{-1})

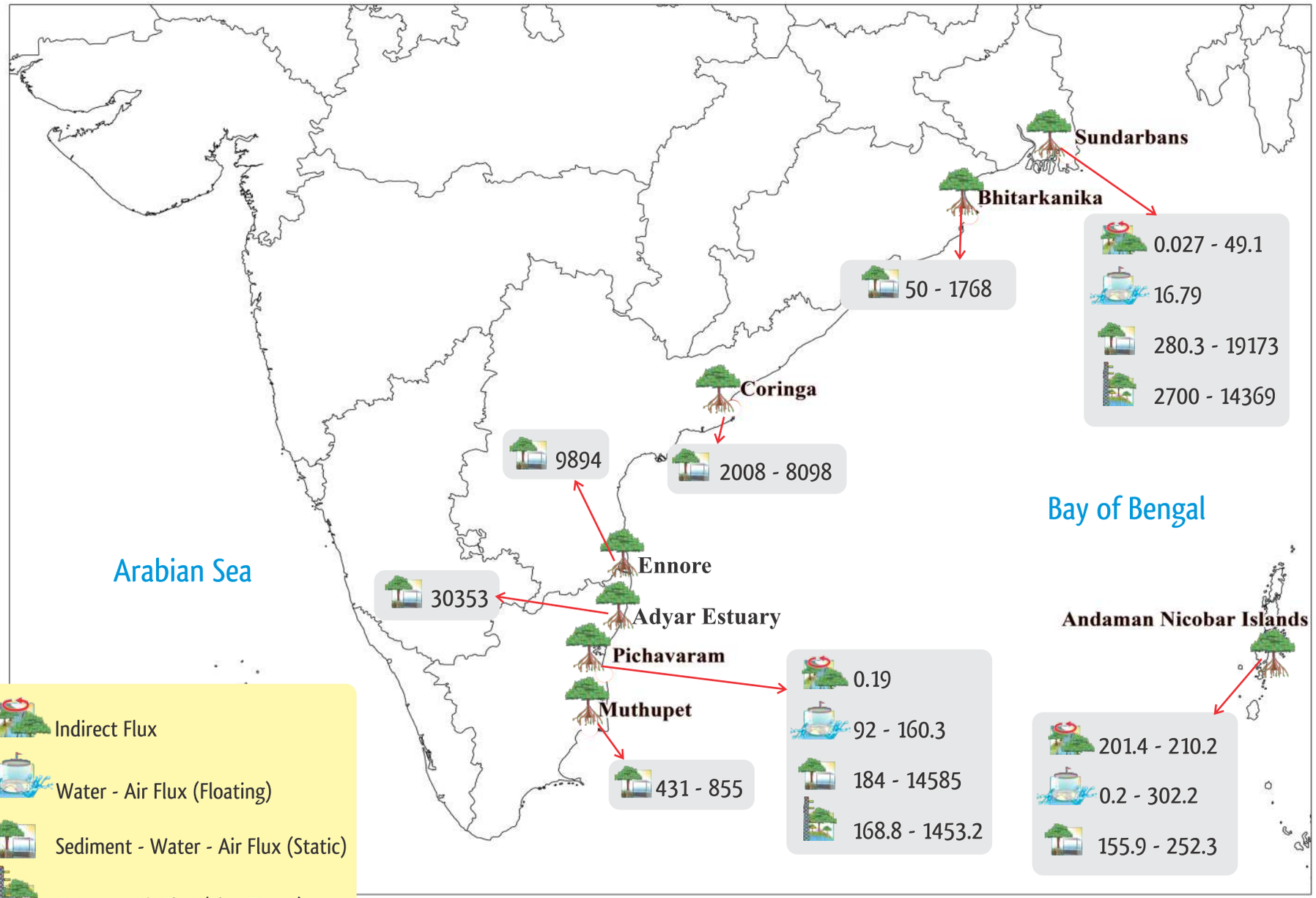


Fig. 2: CH_4 source-sink inventory from Indian Mangroves

N_2O Fluxes from Mangroves (mmol N m^{-2} yr^{-1})

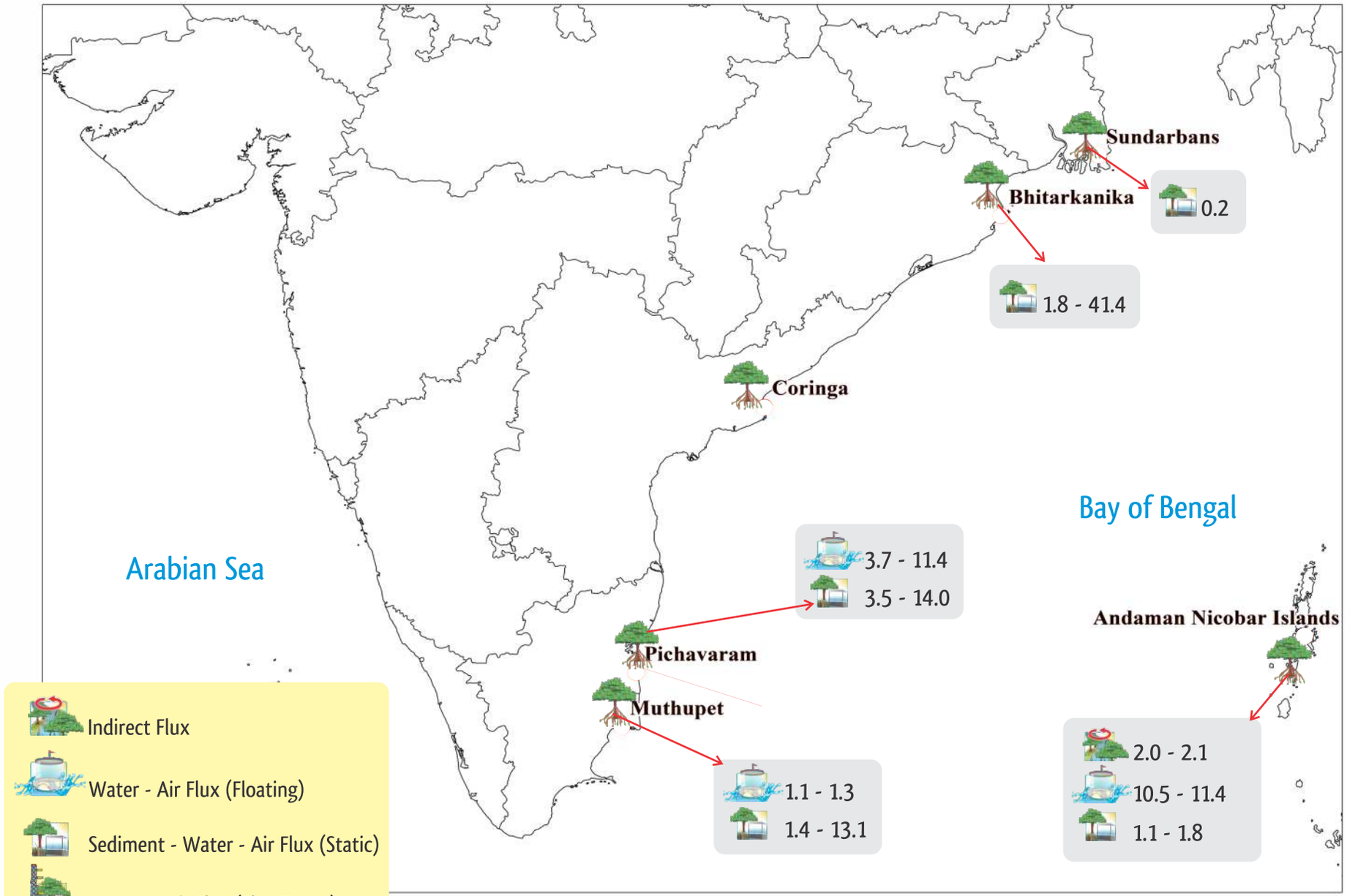


Fig. 3: N_2O source-sink inventory from Indian Mangroves

CO_2 Fluxes from Estuaries (mol C m^{-2} yr^{-1})

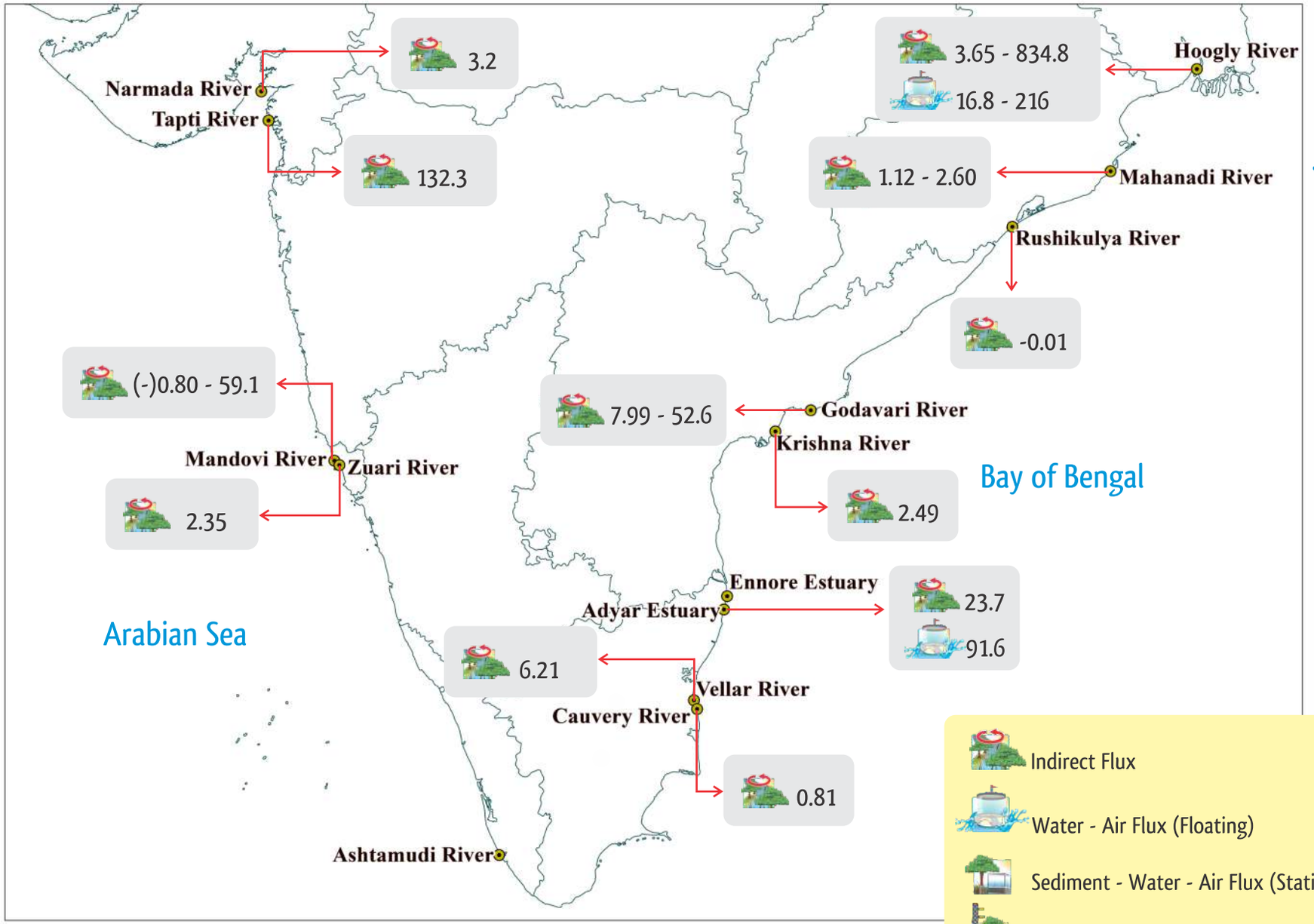


Fig. 4 CO_2 source-sink inventory from Indian Estuaries

FTR

CH_4 Fluxes from Estuaries (mol C m^{-2} yr^{-1})

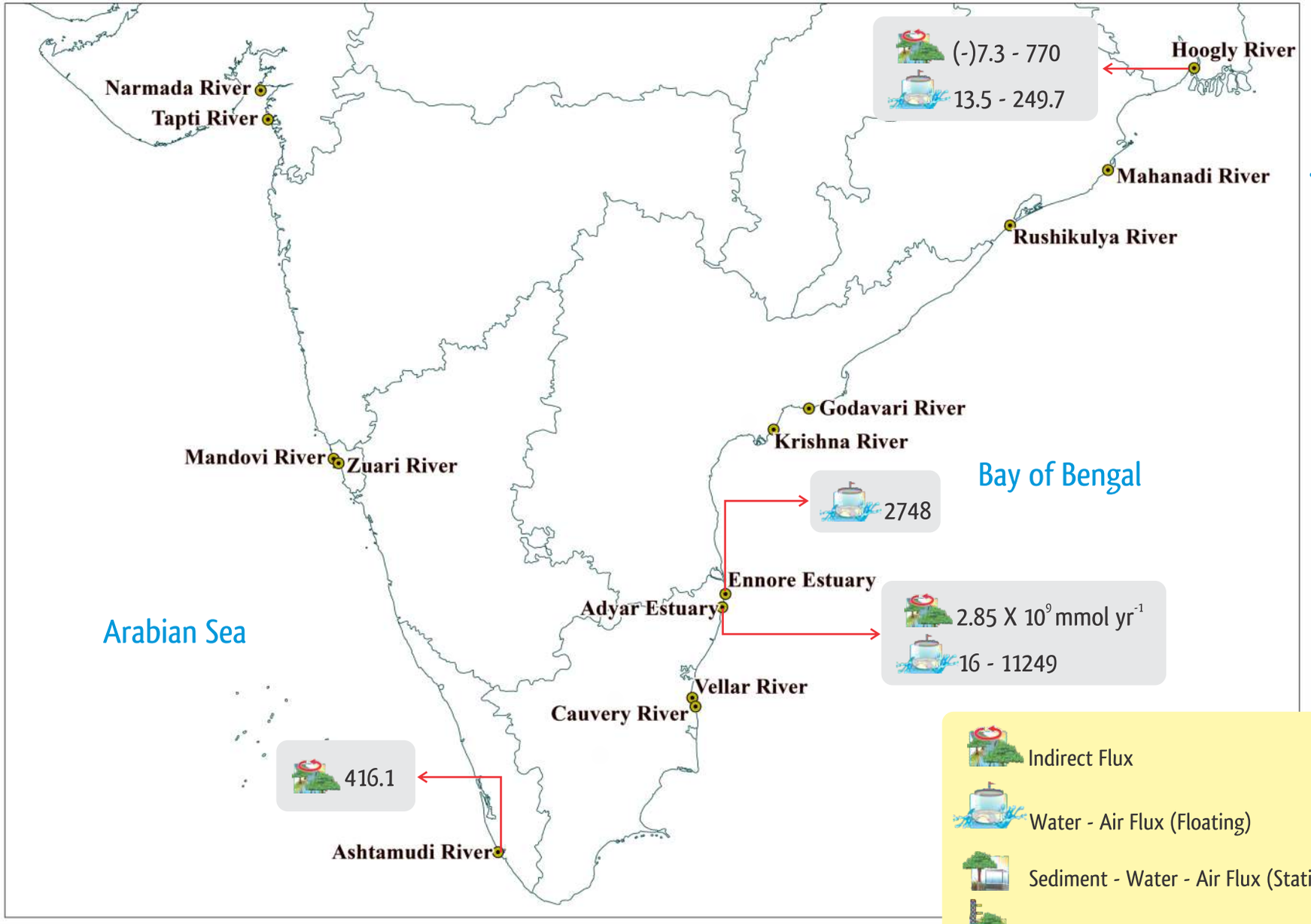


Fig. 5: CH4 source-sink inventory from Indian Estuaries

N_2O Fluxes from Estuaries (mmol N m^{-2} yr^{-1})

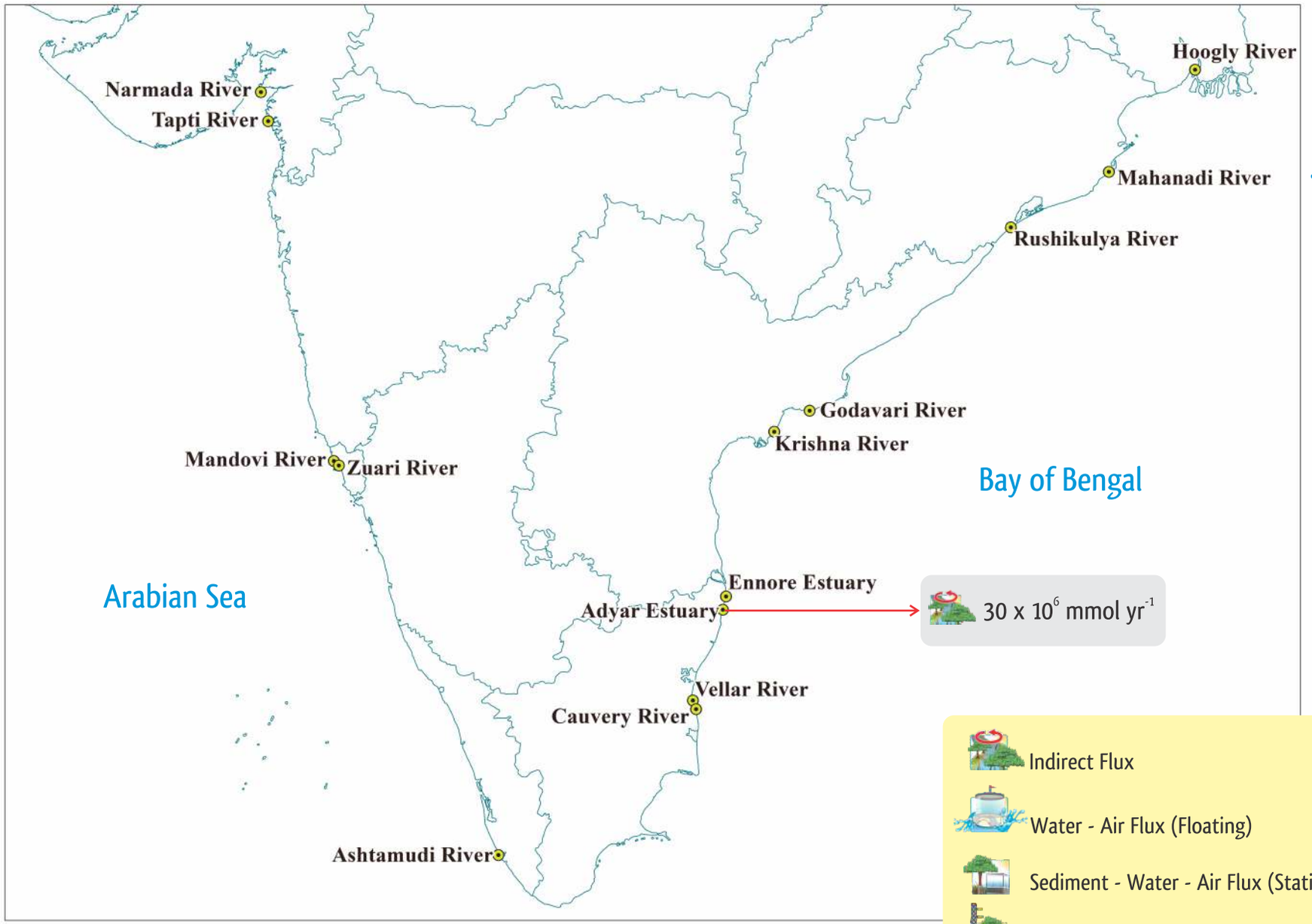


Fig. 6: N_2O source-sink inventory from Indian Estuaries

FTR

CO_2 Fluxes from Lagoon (mol C m^{-2} yr^{-1})

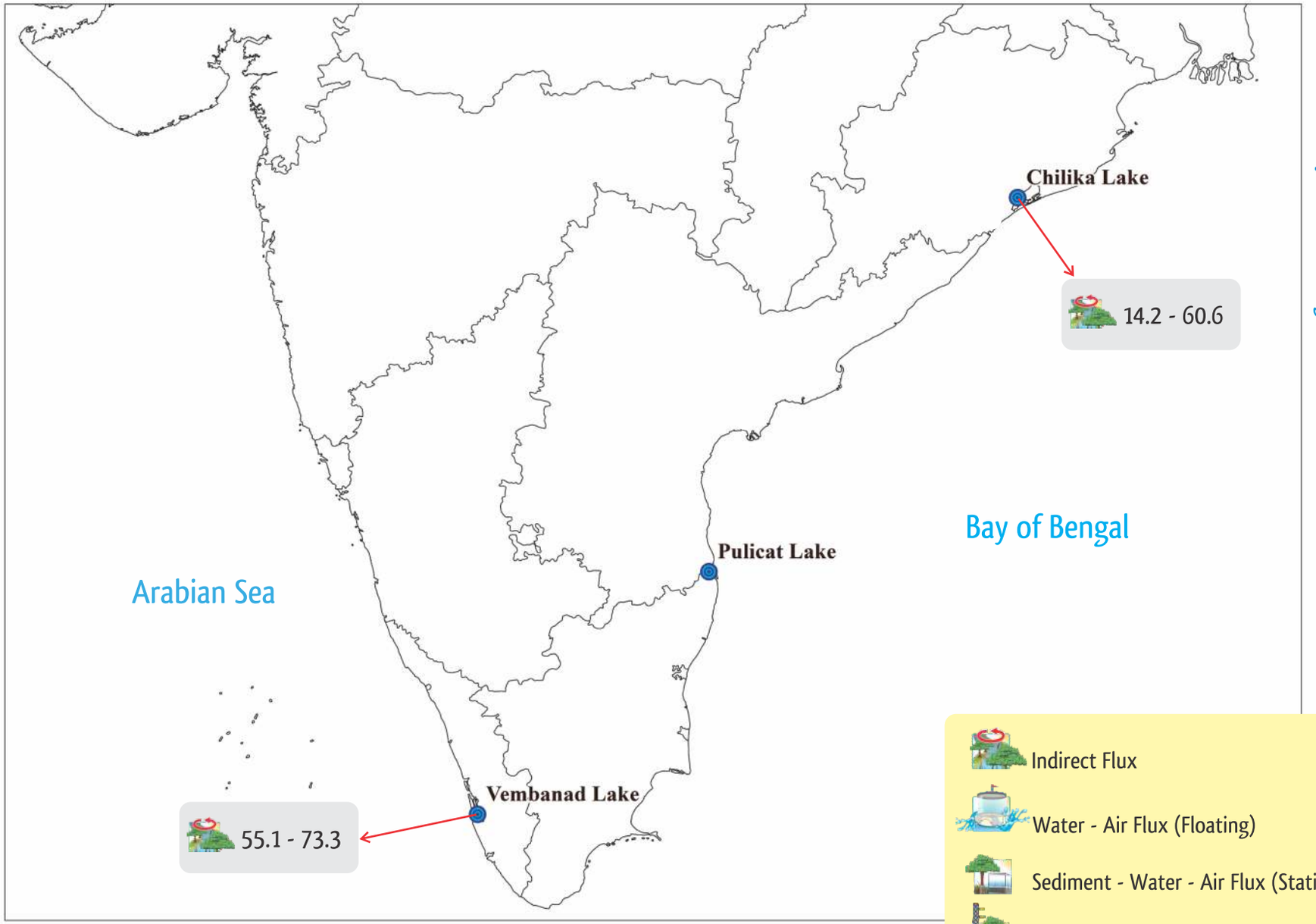


Fig. 7: CO_2 source-sink inventory from Indian Lagoons

CH_4 Fluxes from Lagoon (mmol C m^{-2} yr^{-1})

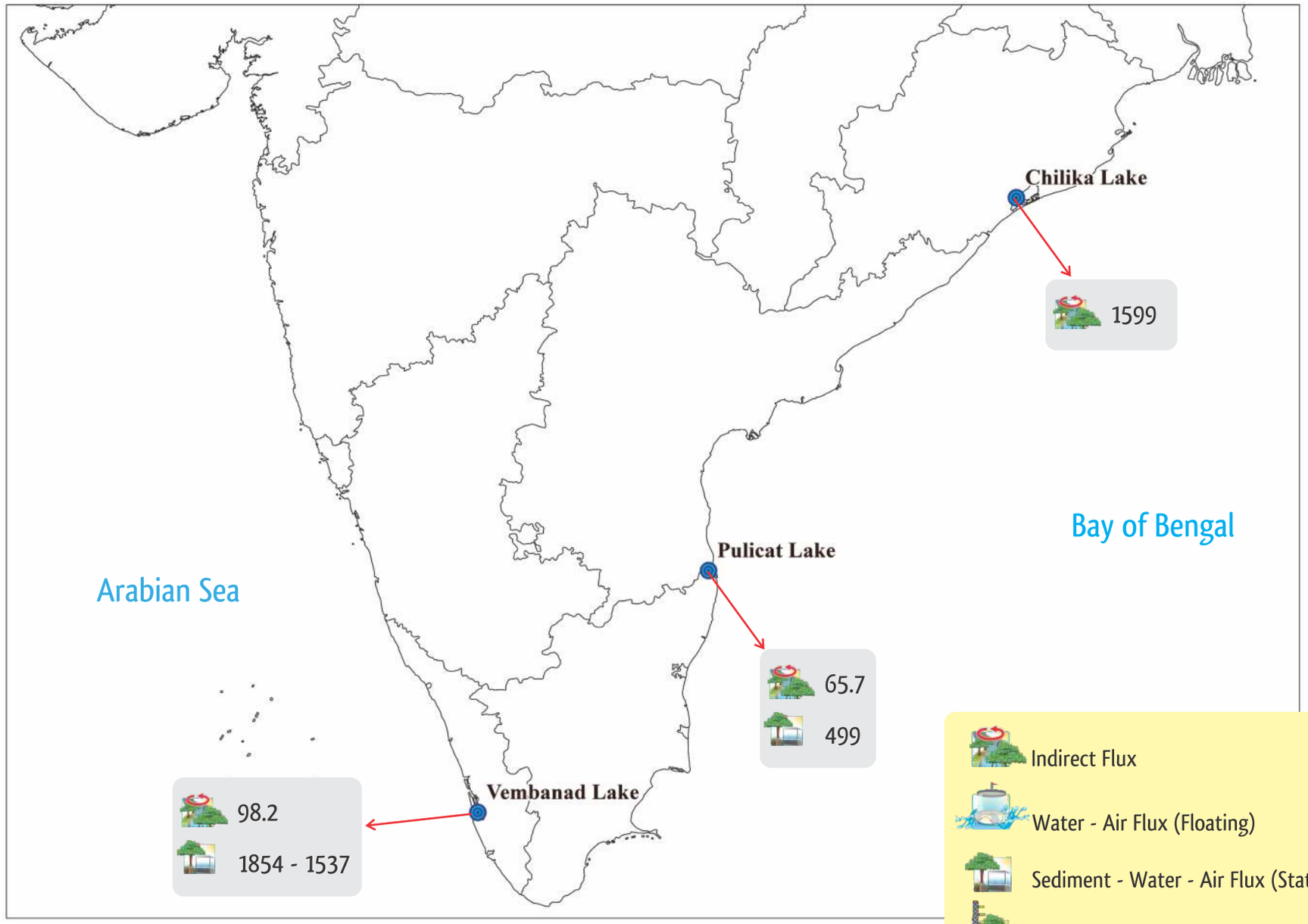


Fig. 8: CH_4 source-sink inventory from Indian Lagoons

FTR

N_2O Fluxes from Lagoon (mmol N m^{-2} yr^{-1})

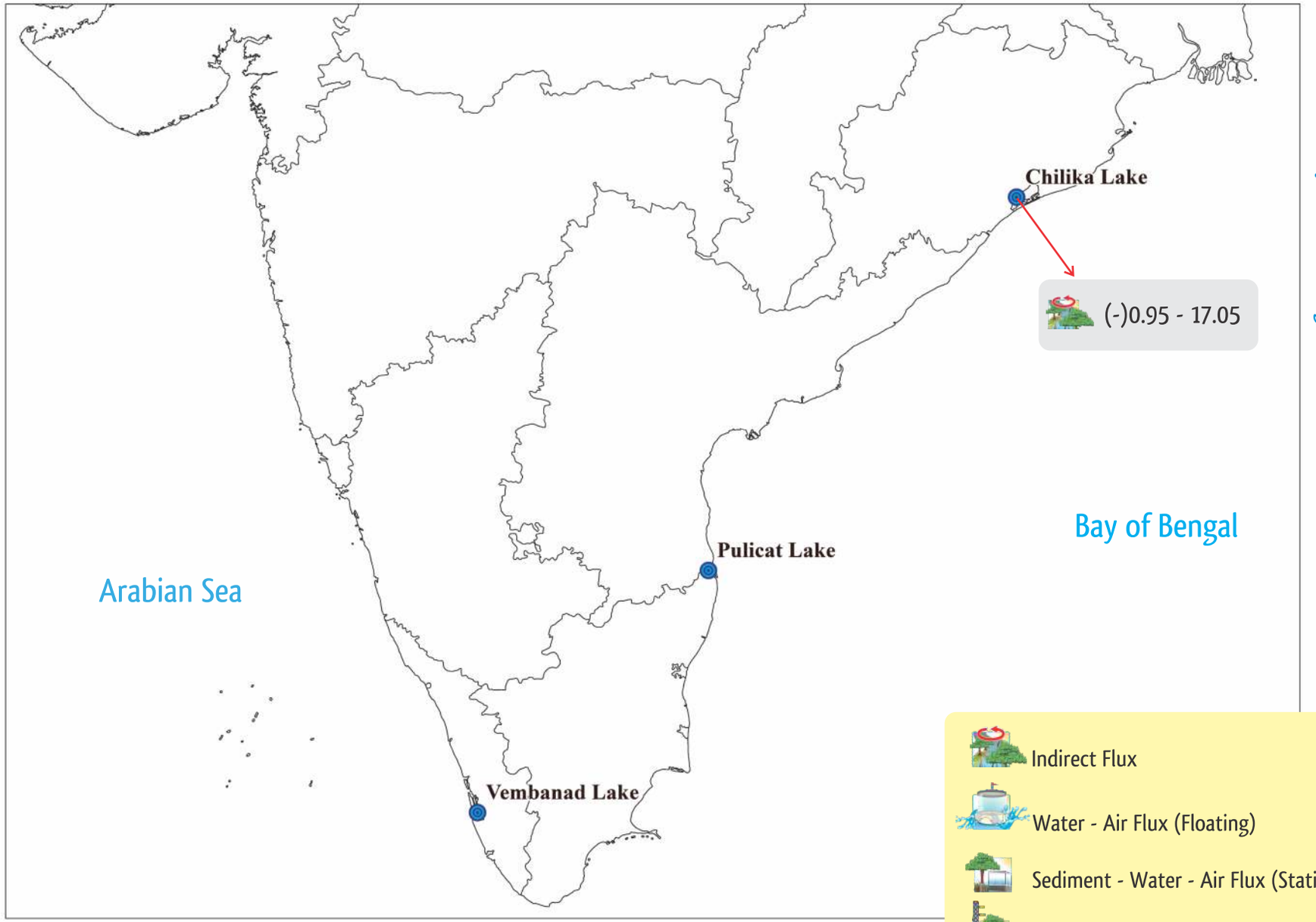


Fig. 9: N2O source-sink inventory from Indian Lagoons

Reference:

1. Barnes, J., Ramesh, R., Purvaja, R., Nirmal Rajkumar, A., Senthil Kumar, B., Krithika, K., Ravichandran, K., Uher, G. and Upstill-Goddard, R. , 'Tidal dynamics and rainfall control N2O and CH4 emissions from a pristine mangrove creek', Geophysical Research Letters, Vol. 33, L15405, doi: 10.1029/2006GL026829, 2006.

2. Biswas, H., Mukhopadhyay, S. K., and De, T. K., Sen, S., and Jana, T. K., "Biogenic controls on the air-water carbon dioxide exchange in the Sundarban mangrove environment, northeast coast of Bay of Bengal, India", Limnol. Oceanogr., 49(1), 95-101, 2004.

3. Biswas, H., Mukhopadhyay, S. K., Sen, S. and Jana, T. K. "Spatial and temporal patterns of 25 methane dynamics in the tropical mangrove dominated estuary, NE coast of Bay of Bengal, India", J. Mar. Syst., Vol. 10, pp. 1-8, 2007.

4. Borges, A. V. and Frankignoulle, M. "Distribution of surface carbon dioxide and air-sea exchange in the English Channel and adjacent areas", J. Geophy. Res., Vol. 108, No. C5, 2003a.

5. Borges, A. V., Delille, B. and Frankignoulle, M. "Budgeting sinks and sources of CO2 in the coastal ocean: Diversity of ecosystems counts", Geophys. Res. Lett., Vol. 32, No. L14601, doi:10.1029/2005GL023053, 2005.

6. Borges, A. V., Djenidi, S., Lacroix, G., The´ate, J., Delille, B. and Frankignoulle, M. "Atmospheric CO2 flux from mangrove surrounding waters", Geophysical Research Letters, doi:10.1029/2003GL017143, Vol. 30, pp. 11-14, 2003b.

7. Borges, A. V., Vanderborght, J. P., Schiettecatte, L. S., Gazeau, F., Ferrón, S., Delille, B. and Frankignoulle, M. "Variability of the Gas Transfer Velocity of CO2 in a Macrotidal Estuary (the Scheldt)", Estuaries, Vol. 27, No. 4, pp. 593-603, 2004.

8. Chanda, A., Akhand, A., Manna, S., Dutta, S., Das, I., and Hazra, S., "Spatial variability of atmosphere-biosphere CO2 and H2O exchange in selected sites of Indian Sundarbans during summer", Tropical Ecology, 54(2), 167-178, 2013.

9. Chauhan, R., Ramanathan, A. L. and Adhya, T. K., "Assessment of methane and nitrous oxide flux from mangroves along Eastern coast of India", Geofluids, 8, 321–332, 2008.

10. Chen, C. T. A. "Exchanges of Carbon in the Coastal Seas", In: Raupach, C. B. F. A. M. R. Ed., The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World. Island Press, Washington DC.9) zx99, 2004.

11. Chen, C. T. A. and Borges, A. V. "Reconciling opposing views on carbon cycling in the coastal ocean: Continental shelves as sinks and near-shore ecosystems as sources of atmospheric CO2", Deep Sea Res II, Vol. 56, No. 8-10, pp. 578-590, 2009.

12. Ganguly, D. , Dey, M., Chowdhury, C., Pattnaik, A. A. , Sahu, B. K. , Jana, T. K., "Coupled micrometeorological and biological processes on atmospheric CO2 concentrations at the landeocean boundary, NE coast of India", Atmospheric Environment, pp. 1-8, 2010.

13. Ganguly, D., Dey, M., Mandal, S. K., De, T. K., and Jana, T. K., "Energy dynamics and its implication to biosphere–atmosphere exchange of CO2, H2O and CH4 in a tropical mangrove forest canopy", Atmospheric Environment, 42, 4172–4184, 2008.

14. Ghosh, S., Jana,T. K., Singh, B. N., Choudhury, A., "Comparative study of carbon dioxide system in virgin and reclaimed mangrove waters of Sundarbansd using freshet", Mahasagar: Bulletin of the National Institute of Oceanography, 20(3), 155–161, 1987.

15. Gupta, G. V. M., Sarma, V. V. S. S., Robin, R. S., Raman, A. V., Jai Kumar, M., Rakesh, M. and Subramanian, B. R. "Influence of net ecosystem production in transferring riverine organic carbon to atmospheric CO2 in a tropical coastal lagoon (Chilika Lake, India)", Biogeochemistry, Vol. 87, pp. 265-285, 2008.

16. Gupta, G. V. M., Thottathil, S. D., Balachandran, K. K., Madhu, N. V., Madeswaran, P. and Nair, S. "CO2 Supersaturation and Net Heterotrophy in a Tropical Estuary (Cochin, India): Influence of Anthropogenic Effect Carbon Dynamics in Tropical Estuary", Ecosystems, Vol. 12, No. 7, pp. 1145-1157, 2009.

17. Kakolee Banerjee, "Biogeochemistry of The Hooghly Estuary and The Adjoining Sundarbans Mangrove, India", Ph.D. thesis submitted to Anna University, Chennai, India, 2012.

18. Krithika, K., Purvaja, R. and Ramesh, R. "Fluxes of methane and nitrous oxide from an Indian mangrove", Current Science, Vol. 94, No. 2, p. 25, 2008.

19. Krupadam, R. J., Ahuja, R., Watea, S. R., Anjaneyulu, Y., "Forest bound estuaries are higher methane emitters than paddy fields: A case of Godavari estuary, East Coast of India", Atmospheric Environment, 41, 4819–27, 2007.

20. Mukhopadhyay, S. K., Biswas, H., Das, K. L., De, T. K., and Jana, T. K. "Diurnal variation of carbon dioxide and methane exchange above Sundarbans mangrove forest, in NW coast of India", Indian Journal of Marine Sciences, Vol. 30, pp. 70-74, 2001.

21. Mukhopadhyay, S. K., Biswas, H., De, T. K., Sen, S. and Jana, T. K. "Seasonal effects on the air-water carbon dioxide exchange in the Hooghly estuary, NE coast of Bay of Bengal, India", J. Environ. Monit., Vol. 4, pp. 549-552, 2002.

22. Neetha, V. "Dissolved carbon dioxide and methane in estuaries and waters surrounding mangroves on the East coast of India and the Andaman Islands", Ph.D. thesis submitted to Anna University, Chennai, India, 2008.

23. Nirmal Kumar, J. I., Kumar, R. N. and Viyol, S. "Dissolved Methane Fluctuations in Relation to Hydrochemical Parameters in Tapi Estuary, Gulf of Cambay, India", Int. J. Environ. Res., 4(4):893-900 , Autumn 2010.

24. Nirmal Rajkumar, A., Barnes, J., Ramesh, R., Purvaja, R. and Upstill-Goddard, R. C. "Methane and nitrous oxide fluxes in the polluted Adyar River and estuary", SE India. Marine Pollution Bulletin, Vol. 56, pp. 2043-2051, 2008.

25. Paneer selvam, A, Biogeochemical fluxes of nutrients and carbon from Vembanad lake, southwest coast of India, Ph.D Thesis, 2013.

26. Pradipta R. Muduli , Vishnu Vardhan Kanuri , R.S. Robin , B. Charan Kumar , Sivaji Patra , A.V. Raman , G. Nageswarara Rao , B.R. Subramanian, "Spatio-temporal variation of CO2 emission from Chilika Lake, a tropical coastallagoon, on the east coast of India", ECSS, pp 1-9, 2012.

27. Purvaja, R. and Ramesh, R. "Natural and anthropogenic methan emission from wetlands of south India", Environ. Manage., Vol. 27, pp. 547-557, 2001.

28. Purvaja, R. and Ramesh, R., "Human impacts on methane emission from mangrove ecosystems in India", Regional Environmental Change, Vol. 1, pp. 86-97. 2000.

29. Purvaja, R., Ramesh, R. and Frenzel P., "Plant-mediated methane emission from Indian mangroves", Global Change Biology, Vol. 10, pp. 1825-1834, 2004.

30. Purvaja, R., Ramesh, R., Ray, A. K. and Tim Rixen, "Nitrogen cycling: A review of the processes, transformations and fluxes in coastal ecosystems", Current Science, Vol. 94, No. 11, 2008.

31. Rajkumar, N. A., Barnes, J., Ramesh, R., Purvaja, R. and Upstill-Goddard, R.C. "Methane and nitrous oxide fluxes in the polluted Adyar River and estuary, SE India", Marine Pollution Bulletin,Vol. 56, pp. 2043-2051, 2008.

32. Ramesh, R., Purvaja, R., Neetha, V., Divia, J., Barnes, J. and Upstill-Goddard, "CO2 and CH4 Emission From Indian Mangroves and its Surrounding Waters" Greenhouse Gas and Carbon Balances in Mangrove Coastal Ecosystems, Tateda Y. et al (eds.), pp. 153-164, 2007.

33. Ray A. K., "Biogeochemical Fluxes Of Carbon And Nitrogen From Chilika Lake, East Coast of India", Ph.D Thesis, 2010.

34. Sarma, V. V. S. S., Viswanadham, R., Rao, G. D., Prasad, V. R., Kumar, B. S. K., Naidu, S. A., Kumar, N. A., Rao, D. B., Sridevi, T., Krishna, M. S., Reddy, N. P. C., Sadhuram Y., and Murty, T. V. R., "Carbon dioxide emissions from Indian monsoonal estuaries", Geophysical Research Letters, VOL. 39, L03602, doi:10.1029/2011GL050709, 2012.

35. Senthilkumar, B., "Biogeochemical And Biophysical Aspects Of Pichavaram Mangrove Ecosystem, South India", Ph.D. thesis submitted to Anna University, Chennai, India, 2007.

36. Shalini, A., Ramesh, R., Purvaja, R., Frenzel, P. and Barnes, J. "Spatial and temporal distribution of methane in an extensive shallow estuary, South India", J. Earth Syst. Sci., Vol. 115, pp. 451-460, 2006.

37. Steven Bouillon, Michel Frankignoulle, Frank Dehairs, Branko Velimirov, Alexander Eiler, Gwenae¨l Abril, Henri Etcheber, and Alberto Vieira Borges, "Inorganic and organic carbon biogeochemistry in the Gautami Godavari estuary (Andhra Pradesh, India) during pre-monsoon: The local impact of extensive mangrove forests", Global Biogeochemical Cycles, VOL. 17, NO. 4, 1114, doi:10.1029/2002GB002026, 2003.

38. Upstill-Goddard, R. C. "Air-sea gas exchange in the coastal zone", Estuarine, Coastal and Shelf Science, Vol. 70, pp. 388-404, 2006.

39. Verma, A., Subramanian, V. and Ramesh, R. "Methane emissions from a coastal lagoon: Vembanad Lake, West Coast, India", Chemosphere, Vol. 47, pp. 883-889, 2002.

40. Zachariah, E. J. and Johny, C. J. "Methane in Estuarine Discharges to coastal Ocean- A study at Ashtamudi Estuary, Kerala, India", Asian Journal of Water, Environment and Pollution, Vol. 6, No. 2, pp. 15-22, 2010.

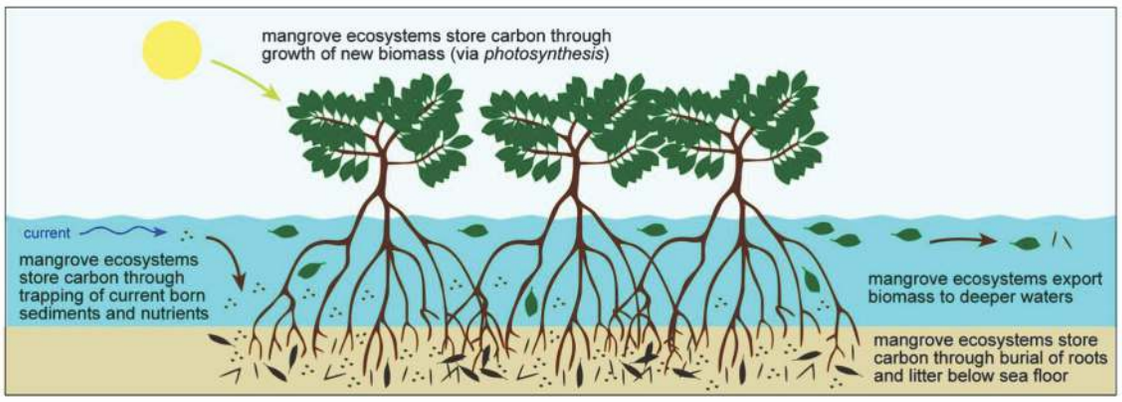
Blue Carbon

Offsetting carbon emissions by conserving coastal vegetation

Introduction

Marine and coastal ecosystems, specifically mangroves, tidal marshes, and seagrasses, are systems that are recognized for their role in mitigating global climate change through the storage and sequestration of carbon dioxide. These ecosystems are also vitally important to the livelihoods of many in coastal communities around the world, through a myriad of ecosystem goods and services they provide. Blue Carbon is "biologically fixed" by marine vegetation and microorganisms and sequestered by burial in sediments and when left undisturbed, blue carbon repositories are secure for millennia. Fig. 1 presents the carbon sequestration potential of mangrove ecosystems.

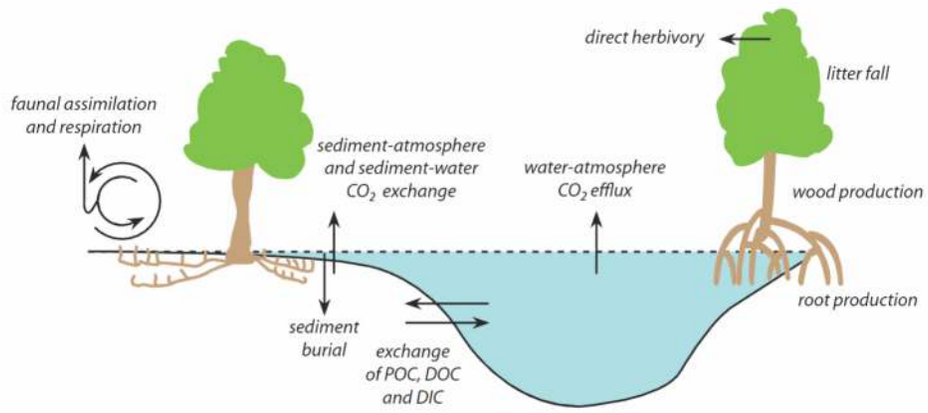
Fig. 1: Mangrove carbon function[4]



Coastal ecosystems cover less than 2% of the total area of the ocean, but account for approximately 50% of the total carbon sequestered in the ocean sediments. They accumulate and store carbon in their plant matter, roots and ultimately to the soil by natural processes. It is believed that the rates of carbon sequestration and storage in these coastal ecosystems are comparable to, and often higher than, the rates in carbon-rich terrestrial ecosystems such as tropical rainforests or freshwater peat lands. Coastal vegetation also continues to sequester carbon for thousands of years in contrast to forests, where soils can become carbon-saturated relatively quickly (Fig. 2). Therefore, carbon offsets based on the protection and restoration of coastal vegetation could be far more cost effective than current approaches focused on trees. Furthermore, there would be enormous add-on benefits to fisheries, tourism and in limiting coastal erosion from the conservation of blue carbon.

[4] http://www.bluecarbonportal.org/wp-content/uploads/2012/08/Eye_Earth_Summit_AGEDI_GRID_Breakout-Session_Dec11.pdf

Fig. 2: Carbon exchange between atmosphere, biosphere and hydrosphere



Source: Bouillon et al. (2008)

There is uncertainty about global blue carbon sink rates, due to uncertainties in ecosystems' areal extent as well as variability in carbon burial rates among individual ecosystems. Hence, independent estimation of blue carbon sink of ecosystem is necessary for more precise quantification to minimize the uncertainty.

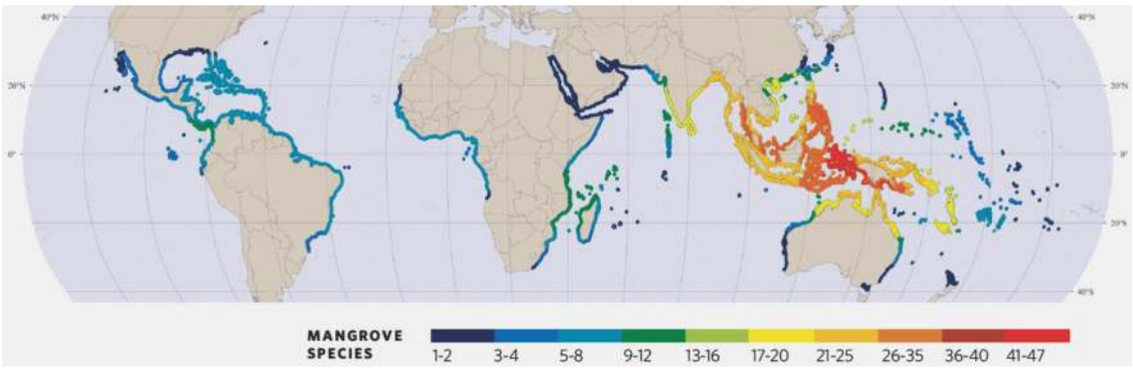
However, we do not have good estimates of how much carbon is sequestered by such ecosystems and the full details of the processes involved. This is of importance as coastal ecosystems are highly threatened because of anthropogenic activities such as conversion (for agriculture, aquaculture, settlements, and industries), pollution and over-harvesting. While these ecosystems have very high potential for long term carbon sequestration, when degraded or destroyed, they can become sources of CO2 emissions, due to oxidization of biomass and organic matter stored in the sediment (Fig. 2). Hence, it is necessary to understand the carbon fluxes in coastal ecosystems. For this, a background study has been undertaken and some of the highlights are given here.

Carbon accumulation in coastal ecosystems

A large number of studies have focused on mangroves. Mangroves accumulate most of their carbon on the ocean floor and the silt that they accumulate raises the ground level. This means that 'as the levels of both the ocean surface and the mangroves soil rise, so too does the amount of carbon sequestered in the earth – and it can stay there for millennia'[5]. Mangroves play an important role in controlling erosion as well as stabilizing shorelines against rising sea levels and are ultimate natural buffers against increasing frequency and intensity of storms, hurricanes and destructive wave action. However, they are facing severe threat from anthropogenic developments. One fifth of the world's mangroves, an area of 35,000km^2 are believed to have been lost in the last 25 years. Global carbon burial in mangrove forests is approximately 18.4 Tg C yr^{-1} (Fig. 3).

[5] Zwick, Steve. Cancun: The Allure – and Elusiveness – of Mangroves as Carbon Sinks. 30 Nov 2010. http://www.ecosystemmarketplace.com/pages/dynamic/article.page.php?page_id=7441&section=home

Fig. 3: Global Mangrove Regions

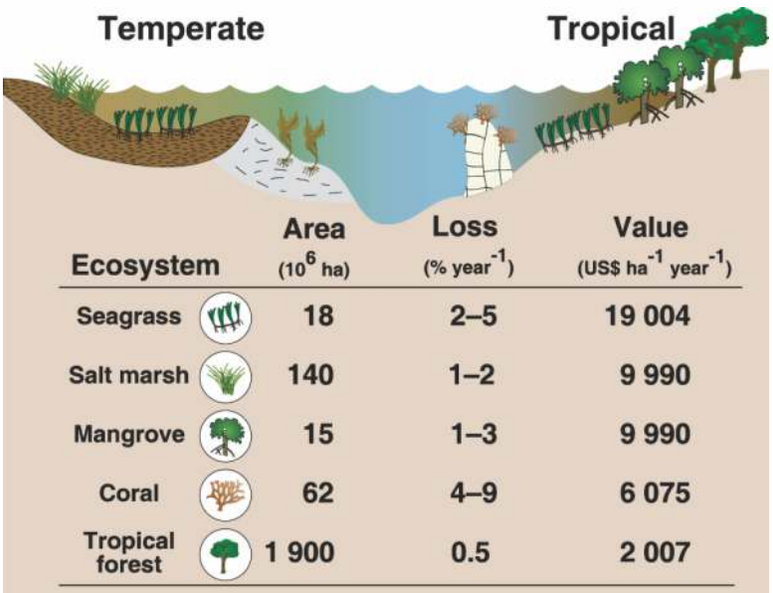


Source: publicwiki.deltares.nl

The process is similar in seagrasses, and is even less visible as seagrass ecosystems are not visible above the water. Studies have indicated that seagrasses are responsible for about 15% of total carbon storage in the ocean. The global extent of seagrass is now estimated to be about 0.3 million km2. Seagrasses efficiently hold sediments in place, preventing re-suspension and movement of sediment deposits. Seagrasses are valuable and threatened compared to other major marine habitats. Similar to mangrove ecosystems, studies on seagrasses have emphasized that conserving and restoring seagrass meadows may reduce greenhouse gas emissions and increase carbon stores as these areas are the hot-spots for carbon sequestration. Carbon accumulates in seagrasses over time and is stored almost entirely in the soils, which have been measured up to four meters deep.

Carbon fingerprinting techniques allow calculating the age of sediment deposits, and therefore, the rate of carbon burial and ultimately identify the contribution of carbon produced by the system. Recent studies have shown that coastal seagrass beds store up to 83,000 metric tons of carbon per square kilometer, which is 27.4Tg of C per year, predominantly in the sediments beneath them (Table 1). Per hectare, seagrasses can store up to twice as much carbon than terrestrial forests (Fig. 4). Seagrass meadows also filter sediment and other nutrients from the water and constantly build and secure sediment, which buffers coasts from erosion, storms and flooding.

Fig. 4: Carbon sequestration Capability of Tropical and Temperate Ecosystems



Ecosystem	Area (10^6 ha)	Loss (% $year^{-1}$)	Value (US$ ha^{-1} $year^{-1}$)
Seagrass	18	2–5	19 004
Salt marsh	140	1–2	9 990
Mangrove	15	1–3	9 990
Coral	62	4–9	6 075
Tropical forest	1 900	0.5	2 007

Source: Duarte et al, 2008, Estuaries and Coasts, 31: 3, p 605

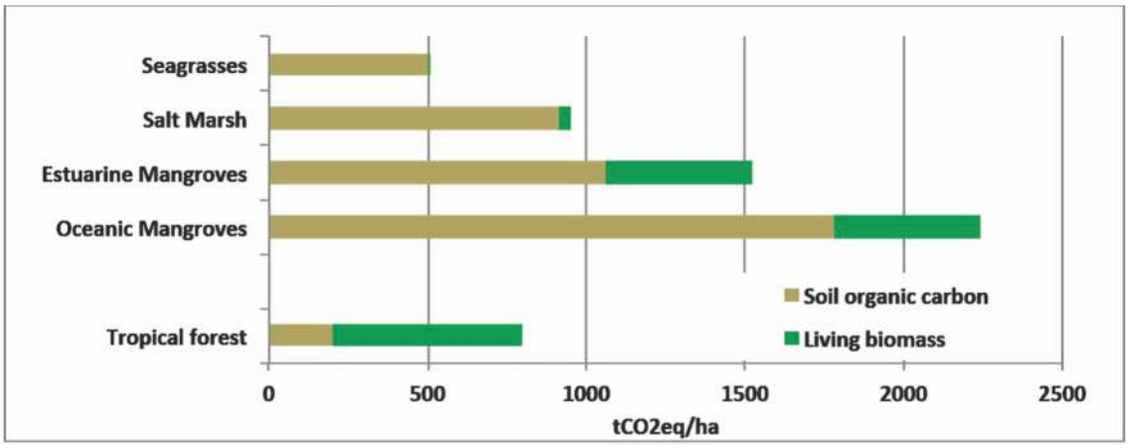
Table 1: Long-term rate of carbon accumulation in coastal sediment

Ecosystem type	Standing carbon stock (gC per m^2)	Total global area (*1012 m^2)	Global carbon stocks (PgC)[8]	Longterm rate of carbon accumulation in sediment (gC per m^2 per year)		
	Plants	Soil		Plants	Soil	
Tidal Salt Marshes			Unknown (0.22 reported)			210
Mangroves	7990		0.157	1.2		139
Seagrass meadows	184	7000	0.3	0.06	2.1	83
Kelp Forests	120-720	na	0.02-0.4	0.009-0.02	na	na

[6] UNEP/GRID-Arendal, Carbon Cycle, UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/carbon-cycle1 (Accessed 6 April 2011)
[7] Chmura et al. 2003 - Global carbon sequestration in tidal, saline wetland soils
[8] PgC. - One petagram=one billion metric tons

Seagrasses contribute towards long-term carbon burial of 83 g C m^{-2} y^{-1}; this translates to global storage rates of between 27 and 40 Tg C y^{-1} (Fig. 5). The seagrass Posidonia oceanica is currently thought to be the most effective species in promoting long-term carbon storage.

Fig. 5: Carbon Storage Abilities of Different Habitat Types[6]



*Data is per unit area, where tCO2eq/ha is tons of carbon dioxide equivalents per hectare

Source: Murray, Brian, Linwood Pendleton, W. Aaron Jenkins, and Samantha Sifleet. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NI R 11-04

[6] Murray, B., Pendleton, L., Jenkins, W.A. and Sifleet, S. 2011. Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholas Institute Report. NI R 11-04

Global Research on Blue Carbon

Studies on Blue carbon have been mainly focused on the burial processes of plant detritus, but other form of organic carbon might also be important in the processes of carbon sequestration. This process also concerns the fate of macro algal organic matter is dissolved organic matter (DOM). Although most of the estimates on the fate of macro algal products did not include this fate[7], macro algae would release a considerable fraction of their productivity as DOM (20-40%)[8].

Since, the role of DOM in carbon sink strongly depends on the bioavailability[9], bio-refractory fraction of macro algal DOM. Hence, DOM should be considered in the process of Blue Carbon. Bioavailability of macro algal DOM has been examined by Wada et al.[10], with dark incubation experiment in which they showed relatively high bio-refractory property of macro algal DOM for microbial decomposition compared with phytoplanktonic DOM. Although, such information is still limited, it indicates the possibility that macro algal DOM acts as a carbon sink in marine environment. In addition to the microbial activity, photo decomposition is also an important factor controlling DOM decomposition. It has been known that a part of marine bio-refractory DOM is readily decomposed by UV radiation[11], and macro algal DOM also has UV-sensitive characteristics[12]. In addition, macro algal DOM would be exposed to strong solar radiation immediately after the release, because UV is able to penetrate to shallow region. Considering these facts, further experiment for microbial availability and photo reactivity will show the contribution of macro algal DOM to Blue Carbon. DOM is also released from other coastal community such as salt marsh[13], mangrove forest[14] and seagrass meadows[15], and they have been also less considered in the processes of Blue Carbon. It might be necessary to take into consideration the role of DOM derived from the macro-phytobenthos in the processes in Blue Carbon as well as macro algae.

[7] Duarte C.M., Cebrian J (1996) The fate of marine autotrophic production. Limnol Oceanogr 41: 1758-1766.

[8] Wada S, Aoki MN, Tsuchiya Y, Sato T, Shinagawa H, et al. (2007) Quantitative and qualitative analyses of dissolved organic matter released from Ecklonia cava Kjellman, in Oura Bay, Shimoda, Izu Peninsula, Japan. J Exp Mar Biol Ecol 349: 344-358.

[9] Carlson CA (2002) Biogeochemistry of marine dissolved organic matter. Academic Press San Diego 91-151.

[10] Wada S, Aoki MN, Mikami A, Komatsu T, Tsuchiya Y, et al. (2008) Bioavailability of macroalgal dissolved organic matter in seawater. Mar Ecol Prog Ser 370: 33-44.

[11] Moran MA, Zepp RG (1997) Role of photoreactions in the formation of biologically labile compounds from dissolved organic matter. Limnol Oceanogr 42: 1307-1316.

[12] Hulatt CJ, Thomas DN, Bowers DG, Norman L, Zhang C (2009) Exudation and decomposition of chromophoric dissolved organic matter (CDOM) from some temperate macroalgae. Est Coast Shelf Sci 84: 147-153.

[13] Moran MA, Pomeroy LR, Shppard ES, Atkinson LP, Hodson RE (1991) Distribution of terrestrially derived dissolved organic matter on the shoutheastern US continental shelf. Limnol Oceanogr 36: 1134-1149.

[14] Dittmar T, Hertkorn N, Kattner G, Lara RJ (2006) Mangroves, a major source of dissolved organic carbon to the oceans. Global Biogeochem Cycles 20: Gb1012.

[15] Ziegler S, Benner R (1999) Dissolved organic carbon cycling in a subtropical seagrass-dominated lagoon. Mar Ecol Prog Ser 180: 149-160.

Coral Reef Ecosystems

The preponderance of reef carbon sequestration is inorganic carbon. Effectively, organic carbon production can be ignored. This is consistent with the observation that the $CaCO_3$ percentage in reef sediments is close to 100% (so inorganic carbon percentage is close to 12% by mass), while the organic carbon percentage is typically ~0.5%. These proportions imply that inorganic carbon accounts for about 95% of carbon burial in reef sediments. If, we take the reef area to be 0.6 x 1012 m^2 and the $CaCO_3$ burial to be ~1,200 g m^{-2} y^{-1}, then the contemporary accumulation of $CaCO_3$ in coral reefs is ~ 700 Tg y^{-1}.

Current Research Objectives

Regional scale data coverage on carbon stocks in seagrass meadows is sparse for some regions, particularly the Indo-Pacific, Africa and South America. Our Blue Carbon research is currently focused on a pilot project on seagrass ecosystem along the Indian coast. Along with this, greenhouse gas (CO_2, CH_4, N_2O) flux data inventorisation has been undertaken from Indian mangroves, estuaries and lagoons. The work plan for this research focuses on the blue carbon ecosystem by undertaking field surveys on biophysical and chemical factors in the coastal ecosystems, including:

- Carbon sequestration rates;
- Carbon and other greenhouse gas inventories;
- Geospatial survey on Carbon stock in sediments;
- Geospatial data on coverage rate; and
- Rates of ecosystem loss

The overarching goal is to combine scientific data with socioeconomic data about the value provided by blue carbon ecosystems in order to influence policy toward better mangroves and seagrass protection and management.



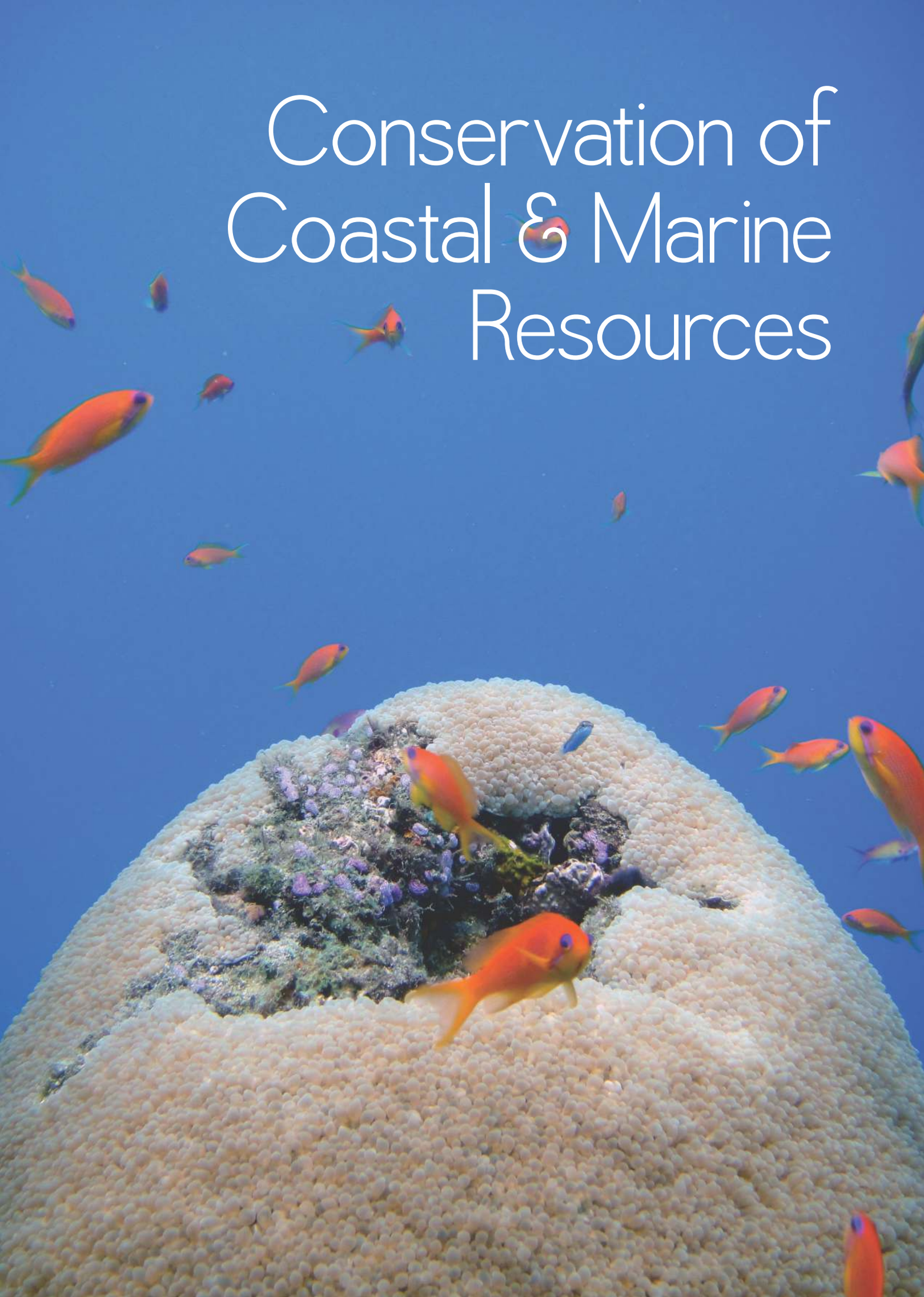
The specific objectives of the present blue carbon research include:

- Inventorization of greenhouse gas flux data from mangrove and seagrass ecosystems of coastal India.
  - Measuring greenhouse gas exchange rates (CO_2, CH_4, N_2O) in mangroves and seagrasses
  - Quantifying blue carbon sequestration rates specifically in mangroves and seagrass ecosystems
  - Monitoring and restoration of mangrove and seagrass ecosystems, following internationally acceptable standard methodologies
- Determining the source of the organic carbon accumulated in sediments of vegetated coastal habitats using isotopes
  - Determine the role of DOM in carbon sink, and its bioavailability
  - Quantify the bio-refractory fraction of macro algal DOM
- Determining sequestering potentials of mangroves and seagreass ecosystems and impacts of oceanographic processes, using modeling and remote sensing data
- Understand impacts of climate anomalies such as ENSO and IOD on coastal and marine ecosystems of India
- Study pattern of mass bleaching events along the Indian coast & project future trends
- Develop coastal conservation, planning and management guidelines for coastal carbon activities.

To Summarize:

- Tropical marine and coastal ecosystems are vulnerable environmental resources that provide significant economic goods and services.
- The health of these ecosystems is critical to human well-being; they contribute to the livelihoods, food security and health of millions of people.
- They play an important role in carbon sequestration, essential for reducing CO2 levels in the atmosphere.
- By accounting for marine ecosystem values in management decisions, we can sustain carbon flow and flow of goods and services in the interest of current and future generations.

Conservation of Coastal & Marine Resources



Delineation of Ecologically Sensitive Areas and Delineation of Critically Vulnerable Coastal Areas (CVCA)

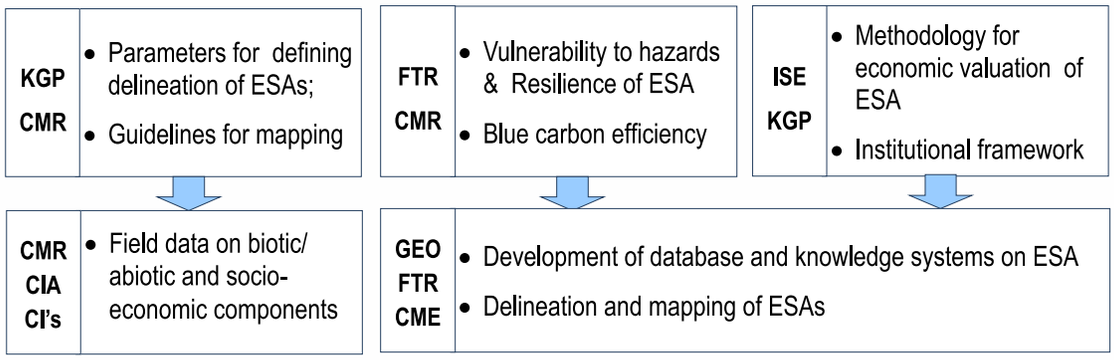
India has a very long coastline with various types of ecosystems viz., tidal mudflats, mangroves, estuaries, lagoons, beaches, marshes, vegetated wetlands, coral reefs etc. Many of these coastal ecosystems, which are known for their rich biodiversity, serve as unique habitats or seasonal nesting sites for specific marine organisms. Over the years, the coastal habitats have been degraded and destroyed due to anthropogenic forces. The government has declared selected coastal and marine areas as protected areas under the Wild Life (Protection) Act, 1972 and Environment (Protection) Act, 1986. However, the contribution of marine protected areas (MPAs) is only 4% of the total protected areas (PAs) and 1.3% of the continental shelf area of the country. The National Environment Policy, 2006 aims at protecting and conserving critical ecological systems and resources which are essential for life support, livelihoods, economic growth and highlights the need for identifying and giving legal status to Environmentally Sensitive Zones in the country and formulate area development plans for these zones on scientific basis, with adequate participation by the local communities.

India's conservation plan is based on the philosophy of identifying and protecting representative sensitive habitats across all the ecosystems. There are already a number of legal instruments to enable protection of identified areas viz., Wild Life (Protection) Act, 1972, Forest (Conservation) Act, 1980 and Environment (Protection) Act, 1986, Indian Forest Act, 1927, Biological Diversity Act, 2002 and Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. The Coastal Regulation Zone (CRZ) 2011 notification, issued under the Environment Protection Act, 1986 classifies the areas that are ecologically sensitive and the geomorphological features which play a role in maintaining the integrity of the coast under CRZ I Category.

Scientific data on the ecologically sensitive areas (ESA) with respect to physical, chemical and biological components with associated issues such as resource use and socio-economics of dependent population are far from complete. Guidelines to designate an area as ESA have been in existence, albeit on broad terms allowing open ended decision making to the state government, thus providing them with avenues to adopt diversified criteria. Further, mapping of all aspects of an ESA would pave way for better management and enforcement of relevant regulatory provisions. In this background, a comprehensive research project has been initiated to define coastal and marine ESAs and identify the parameters for their delineation and demarcation in order to aid in the implementation of the CRZ Notification, 2011.

The project is envisaged to be carried out by the NCSCM scientists, cross cutting the technical divisions involving the experts from Consortium Institutions (CI) from all the coastal states. Some activities will be undertaken simultaneously while some will be carried out sequentially, taking inputs from other activities. Detailed work packages have been made by NCSCM for undertaking the study which was deliberated in the consultative meeting with the CIs. A road map has been prepared for the execution of the project activities with the CIs and external experts.

A broad framework for implementation of the project is given below.



The Coastal Regulation Zone(CRZ) 2011 notification issued under Environment (Protection) Act, 1986 has brought a new coastal area under the regulatory regime, the Critical vulnerable coastal areas (CVCA), which represents the area requiring special consideration for protecting the critical coastal environment with the involvement of coastal communities including fisher folk.

As a first step, a comprehensive list of potential CVCAs will be prepared through experts consultation with representatives of coastal stakeholders, state forest departments, regional NGOs, etc. Then, guidelines for – identifying, planning, notifying and implementing CVCAs will be developed and the potential CVCAs will be evaluated against them. A multi-stakeholder consultation will be held to determine the buffer zones and boundaries of CVCAs. The guidelines for preparation of integrated management plan (IMP) for the CVCAs will be developed through extensive consultations based on the issues of conservation and management of CVCAs, infrastructure needs of the local communities and the impact of sea level rise and other natural hazards. The contemporary and traditional knowledge of the coastal communities on resource use will be utilized in the planning process.

The relationship between changes in natural systems with protection and corresponding changes in socioeconomic welfare is the central focus of ESAs. The present approach with baseline data set on biological, geological and socioeconomic factors would identify the areas of high human impact based on land use, population pressure, infrastructure and access. The positive changes in the ecological conditions through improved biophysical resources and other benefits would be quantified into economic returns. The institutional framework for management of CVCAs would also be developed based on community participation.

This research would aid in accumulating scientific data on the social and ecological aspects of the CVCAs. Further, the local community will be sensitized on the merits of official notification of the area which in turn would also help in garnering wider acceptance among the local population. The spatial maps on ecological features with associated environmental data will form the knowledge base on the nation's ESAs and CVCAs, which in turn would aid in their conservation and sustainable management. It will also help in meeting the country's obligations under the Convention on Biological Diversity (CBD) and other international agreements, without compromising on the interests of the traditional users of coastal and marine areas.

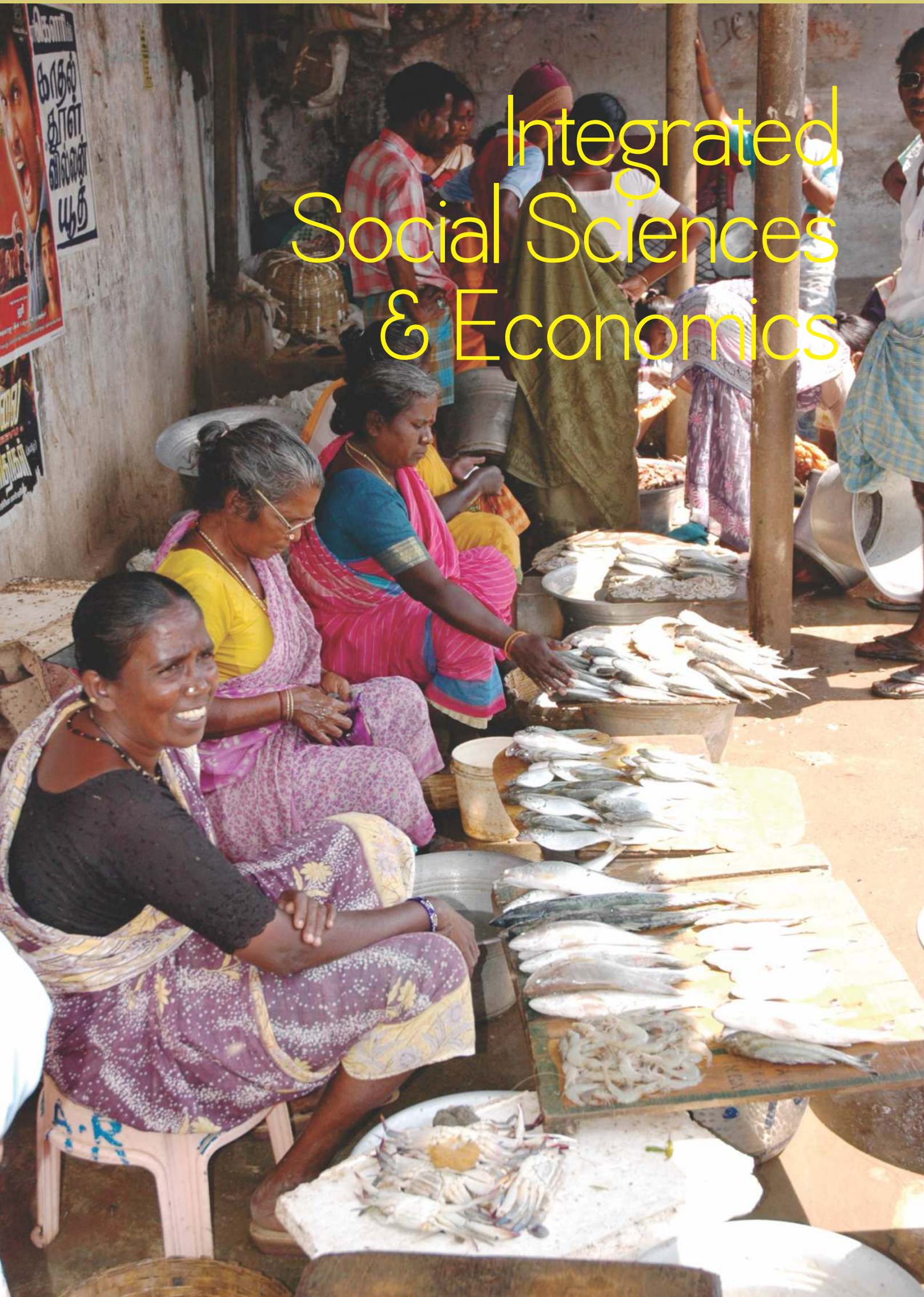
Development of a Database on Marine Diversity

Biodiversity is arguably the most precious resource on the earth. Information about biodiversity is vital to a wide range of scientific, social, educational, medicinal and commercial uses, given the dependence of mankind on natural systems. Our accumulated knowledge about biodiversity and the environment will become ever more important towards developing a sustainable world, following the increasing pressure on the natural ecosystems caused by population growth.

A number of bio-resource databases have been made by various agencies across the world. Some are regional databases, some are on broad classes of habitats, while some are for specific taxa. The Ocean Biographic Information System (OBIS) created by the Census of Marine Life, is now part of the Intergovernmental Oceanographic Commission (IOC) of UNESCO and strives to document the ocean's diversity, distribution and abundance of life. A distinct feature in the documentation of bio-resources of late, is the shift from mere textual documentation to digital formats. Recent developments in the field of information technology, availability of requisite software expertise and the convergence of interests among biologists and government agencies have combined together to provide a clear platform to develop digital databases of bio-resources.

It is envisaged to undertake a systematic study to address the core issues viz., lack of unified national architecture for collection and maintenance of marine biodiversity data; lack of comprehensive database covering biological, geo-spatial and molecular/genetic information and online tools for character-based field identification. The project would help to collate the biodiversity data scattered across the institutions and develop an interactive platform keeping in view of the needs of the current and future uses of the database.

Firstly, the framework of existing national and global databases on biodiversity with special reference to coastal and marine areas will be reviewed. A template incorporating all the desirable features of existing biodiversity databases will be developed keeping in view of the recent technological advances in bioinformatics and taxonomy. The existing gaps in the databases will be determined and a detailed strategy for bridging them through field observations will be delineated. Focused consultations would be held among the experts of specific taxonomic group and a comprehensive database on the morphological and anatomical features used for identification will be developed. The key characters that are crucial for field identification across various taxa of marine biota will be determined, which in turn would aid in real-time field identification of coastal and marine organisms. The program envisages developing a novel technology-driven identification platform which can be scaled up with the emerging information and space technologies.



Integrated Social Sciences & Economics

Economic Valuation of Coastal and Marine Ecosystem Goods and Services in India

The Indian Coastline possesses a vast extent of ecologically sensitive coastal and marine ecosystems. While they are known to provide diverse ecological functions, these are not well documented and studies on their economic valuation are rudimentary. In the absence of quantitative values, it is difficult for the policy makers to arrive at proper decision regarding their utility and need for conservation. NCSCM would jointly work with the consortium partners viz., Madras School of Economics, Chennai and Department of Economics, Goa University, Goa to derive qualitative and quantitative estimates of values for various ecosystems along the coast.

This research aims at mainstreaming the physical value and non-market economic value of coastal ecosystem goods and services for determining (i)the economic losses when infrastructure development projects are undertaken and (ii) the benefits accrued when investment in conservation is proposed. The study envisages developing suitable methodology through expert consultations and comprehensive review of coastal valuation studies in India and also in the context of the South Asian region. The standardized approach will then be used for empirical estimation in the context of coastal ecosystem goods and services for a few coastal marine ecosystems. The long-term changes in various ecosystem services, e.g., changes in freshwater flow, water quality, beach stability (erosion), fish abundance, marine habitat quality, mangroves, biomass, carbon storage and any other ecological attributes would be measured across different conservation areas so as to design stated choice (contingent valuation) and revealed choice (travel costs, and production function approaches) studies.

The research study would improve the understanding of the economic values of coastal ecosystem goods and services and help policy makers incorporate the estimated economic values (market and non-market) into the cost-benefit analysis of coastal development and coastal conservation. Eventually, ecosystem service values will be used to promote effective and participatory management strategies for sustainable use of the coastal resources.

Integrated Island Management

Island Coastal Regulation Zone (ICRZ) Plan and Integrated Island Management (IIM) Plan for the Islands

The Ministry of Environment and Forests under the Environment (Protection) Act, 1986 has notified the Island Protection Zone (IPZ) Notification, 2011 alongside the Coastal Regulation Zone (CRZ), 2011 with the objective of (i)ensuring livelihood security to the fishing communities, tribals and other local communities living in the coastal areas; (ii)conserving and protecting coastal stretches and (iii)promoting development in a sustainable manner based on scientific principles, taking into account the dangers of natural hazards in the coastal areas and sea level rise due to global warming.

There are about 572 islands in Andaman & Nicobar and about 30 in Lakshadweep. These two groups of oceanic islands are home to some of the country's most thriving biodiversity hotspots. While the islands of Middle Andaman, North Andaman, South Andaman and Greater Nicobar in Andaman and Nicobar Islands are to be managed as per the Island Coastal Regulation Zone (ICRZ), the rest of the islands in Andaman and Nicobar and all the islands in Lakshadweep are to be managed in accordance with the Integrated Island Management (IIM) Plan, as provided under the IPZ Notification, 2011.

While preparing an ICRZ plan, the hazard line, which is demarcated based on tides, waves, sea level rise and shoreline changes, would be taken into account. The ICRZ would address vulnerability to human life and properties, based on elevation, geomorphology, sea level trends and horizontal line displacement and indicate suitable areas that are safe for locating dwelling units and other infrastructure. All developmental activities would be regulated within the framework of ICRZ Plan.

The IIM plan would indicate all the existing and the proposed developments, conservation and preservation schemes and dwelling units including infrastructure projects such as, schools, markets, hospitals, public facilities and the like, which would be collected from the respective union territory (UT) administration. Ecologically sensitive areas and the developmental activities in the islands including requirements of the Ministry of Defence would also be taken into consideration while preparing the Integrated Islands Management (IIM) Plan, as specified in the IPZ Notification, 2011. Appropriate safeguard measures to protect the life and property of the local communities and infrastructure from natural hazards would be indicated in the IIM Plan. All developmental activities, listed under the Island Protection Zone Notification, 2011, would be regulated within the framework of IIM Plan of Andaman and Nicobar and Lakshadweep.

NCSCM would develop the process guidelines and extend technical assistance to the island administration in preparing the Island Coastal Regulation Zone (ICRZ) Plan and Integrated Islands Management (IIM) Plan while the respective UT administration would prepare the ICRZ / IIM Plans for regulating developmental activities in their coastal environment.

Recognitions

NCSCM

- Special Achievement in GIS Award – India 2012

Dr. R. Ramesh, Director, NCSCM

- Chairman of the Scientific Steering Committee of the Land Ocean Interaction in the Coastal Zone (LOICZ), core project of the International Geosphere Biosphere Programme IGBP and IHDP (from January 2012 - 2014)
- Member, Scientific Steering Committee of Monsoon Asia Integrated Regional Study (MAIRS) (2013 - 2015)
- Member, National Coastal Zone Management Authority (NCZMA), Ministry of Environment and Forests, Government of India (2011-2014)
- Member, Special Committees constituted by the MoEF [Adani Port, POSCO, Srinagar Hydro Power Project] (2012 – 2013)
- Member, Expert Group to assess safeguards for Tsunami type risks of EIA projects, Ministry of Environment and Forests, Government of India (2012)
- Member, Coastal Zone Management Authority, Government of Tamil Nadu (2012 - 2014)
- Member, Coastal Zone Management Authority, Government of Puducherry (2012 - 2014)
- Member, Coastal Zone Management Authority, Andaman and Nicobar Administration (2012 – 2014)
- Co-Chair, International Waters Science (IW Science) Project of the United Nations University

Dr. Purvaja Ramachandran, Division Chair, FTR

- Coordinator, Regional South Asia Node, of the Land Ocean Interaction in the Coastal Zone (LOICZ), core project of the International Geosphere Biosphere Programme IGBP and IHDP (from January 2013 - 2016)
- Member, International Waters Science (IW Science) Project of the United Nations University

Prof. Ramachandra Bhatta, Division Chair, ISE

Nominated as Member of the Quinquennial Review Team (QRT) by the Secretary, Department of Agricultural Research and Education, Ministry of Agriculture and Director General, Indian Council of Agricultural Research (ICAR), New Delhi for Central Institute of Freshwater Aquaculture, Bubhaneswar.

Publications

Achyuthan, H., Deshpande, R.D., Raoc, M.S., Bhishm Kumar., Nallathambi, T., Shashi Kumar, K., Ramesh, R., Purvaja, R., Maurya, A.S., and Gupta, S.K. (2013) Stable isotopes and salinity in the surface waters of the Bay of Bengal: Implications for water dynamics and palaeoclimate. Marine Chemistry, Volume 149: 51–62 [Impact Factor: 3.551]

Roland von Glasow, R., Jickells, T., Baklanov, A., Gregory R., Carmichael, Church, T., Gallardo, L., Hughes, C., Kanakidou, M., Liss, P., Mee, L., Raine, R., Purvaja, R, Ramesh, R., Sundseth, K., Tsunogai, U., Uematsu, M. and Zhu, T. (2012) Megacities and large urban agglomerations in the Coastal Zone: Interactions between atmosphere, land and marine ecosystems. AMBIO Volume 42, Issue 1, pp 13-28 [Impact factor: 2.025]

Saxena, S., Purvaja, R. Mary Divya Suganya, G. and Ramesh, R. (2012). Coastal hazard mapping in the Cuddalore region, South India. Nat Hazards (2012): 1–10. DOI 10.1007/s11069-012-0362-7 [Impact factor: 1.529]

Gowri, V.S. Ramesh, R., Nammalwar, P., Satheesh, N., Rajkumar, J., Kakolee Banerjee, and Sesha Bamini, N. (2012). GIS approach in assessing the status of neritic water quality and petroleum hydrocarbons in Bay of Bengal (From Chennai to Nagapattinam, Tamilnadu), India. International Journal of Geomatics and Geosciences, Volume 3, No 1. 249-258.

Hariharan, G., Suresh Kumar, C. Laxmi Priya, S. Paneer Selvam, A. Mohan, D. and Purvaja, R. and Ramesh, R. (2012). Acute and chronic toxic effect of lead (Pb) and zinc (Zn) on biomarker response in post larvae of Penaeus monodon (Fabricus, 1798). Journal of Toxicological & Environmental Chemistry. DOI:10.1080/02772248.2012.710412 ISSN 0277–2248 print/ISSN 1029–0486 online 2012 Taylor & Francis.

Paneer Selvam, A. Laxmi Priya, S. Kakolee Banerjee, Hariharan, G., Purvaja, R. and Ramesh, R. (2012). Heavy metal assessment using geochemical and statistical tools in the surface sediments of Vembanad Lake, Southwest Coast of India, Environ Monit. Assess. Vol. 184: 5899-5915. DOI 10.1007/s10661-011-2389-8 [Impact factor: 1.436]

Kakolee Banerjee, B. Senthilkumar, R. Purvaja, R. and Ramesh, (2012) Sedimentation and trace metal distribution in selected locations of Sundarbans mangroves and Hooghly estuary, Northeast coast of India, Environ Geochem Health, Vol. 34: 27–42. [Impact factor: 1.667]

Ramesh R, Lakshmi A, and Purvaja R (2011) Integrated Coastal and Estuarine Management in South and Southeast Asia. In: Wolanski E and McLusky DS (eds.) Treatise on Estuarine and Coastal Science, Vol. 11, pp. 227–263. Waltham: Academic Press.

Voß M, Wannicke N, Deutsch B, Bronk D, Sipler R, Purvaja R, Ramesh R, and Rixen T (2011) Internal Cycling of Nitrogen and Nitrogen Transformations. In: Wolanski E and McLusky DS (eds.) Treatise on Estuarine and Coastal Science, Vol 5, pp. 231–259. Waltham: Academic Press.

Rixen, T., Purvaja, R., Lehnhoff, L., Dasbach, D., Urban, B., Ramesh, R. and Ittekkot, V. (2011). Impact of monsoon-driven surface ocean processes on a coral off Port Blair in the Andaman Islands and their link to North Atlantic climate variations. Global and Planetary Change Volume 75, Issues 1-2, Pages 1-13 [Impact factor: 3.918]

Chapters in Books

Ramesh, R. Ahana Lakshmi, Annie George and R. Purvaja (2013). Climate Change and the Coast: Building Resilient Communities Case Study: India. In: Climate Change and the Coast. Eds. Robert Charles Kay, Ailbhe Travers, Michael Kelly, Bruce Glavovic. Published by Taylor & Francis (in press)

Ahana Lakshmi, Purvaja, R and Ramesh, R. Recovering from the 2004 Indian Ocean tsunami: Lessons for climate change response. In 'Adapting to Climate Change: Lessons from Natural Hazards Planning' (Ed. Bruce C. Glavovic & Gavin Smith) – in press

Ramesh, R., Purvaja, R. and Urban, B. (2011) Assessment of the Tsunami Affected Andaman Islands, India. In: The Indian Ocean Tsunami: The Global Response to a Natural Disaster. Karan, P.P. and Subbiah, S.P. (Eds.) The University Press of Kentucky, 352 pages.

Ramesh, R and Purvaja, R (2011). Capacity building in coastal management. In: Coastal Environment. Bhatt, J.R. (Ed.) IUCN and MoEF Joint Publication 205 - 216; pp. 278

R. Ramesh, R., Purvaja, R., Senthil Vel, A., Ahana Lakshmi., Bhat, J.R. (2011) Coastal Regulation Zone Notification: A Review of the Chronology of Amendments. In: Coastal Environment. Bhatt, J.R. (Ed.) IUCN and MoEF Joint Publication, 219 - 240; pp. 278

Reports

Ramesh, R., Purvaja, R. and Senthil Vel, A. (2011) National Assessment of Shoreline Change: Odisha Coast. Ministry of Environment and Forests Publication

Ramesh, R., Purvaja, R. and Senthil Vel, A. (2011) National Assessment of Shoreline Change: Puducherry Coast. Ministry of Environment and Forests Publication

Ramesh, R., Purvaja, R. and Senthil Vel, A. (2011) Factsheet on National Assessment of Shoreline Change: Odisha Coast. Ministry of Environment and Forests Publication

Ramesh, R. and Purvaja, R. and Ahana Lakshmi (2011) Coastal Pollution Loading and Water Quality Criteria: The Bay of Bengal Coast of India. Bay of Bengal Large Marine Ecosystem (BOBLME) Project, FAO Publication, 235 pp. (in press)

Ramesh, R., Kremer, H., Purvaja, R. and Dansie, A. (2012) Synopsis Report of the Land-based Pollution Sources Working Group. Enhancing the use of Science in International Waters projects to improve project results: Application of science for adaptive management & Development and use of indicators to support IW projects, UNU, Canada

Ramesh, R., Kremer, H., Purvaja, R. and Dansie, A. (2012) Analysis Report of the Land-based Pollution Sources Working Group. Enhancing the use of Science in International Waters projects to improve project results: Application of science for adaptive management & Development and use of indicators to support IW projects

Meetings Organized

Workshops/Seminars/Trainings/ Meetings Organized

NCSCM organized many Workshops/ Seminars/ Trainings and consultations on various topics at Chennai as well as other parts in India, which are summarized below.

No	Particulars	Place	Period
1	Workshop to ensure Fish workers participation in the implementation of CRZ 2011	Koodal Hall,	13-14 Jun 2011
2	Workshop on Coastal Wellbeing Methods	Anna University, Chennai.	
3	National workshop on Integrated Coastal Zone Management project (ICZM) planning	Koodal Hall,	14 - 18 Nov 2011
4	Brain Storming Session on Coastal Lagoons, Lives and Livelihoods at COP 11 Hyderabad, 2012	Anna University, Chennai.	16-17 Mar 2012
5	Delineation of Primary and sub cells for Orissa Coast at Koodal building	Bhubaneswar, Odisha.	5 Sep 2012
6	Erosion Mapping for Hazard Line Mapping	Hyderabad	27 & 28 Dec 2012
7	Workshop on Coastal Ecosystem health Report card of Chilika Lake	Koodal Hall,	08 Jan 2013
8	Interface Meeting with the Consortium Partners	Anna University, Chennai.	04-07 Feb 2013

Significant Milestones

Signing of MoU between Anna University, Chennai and Ministry of Environment and Forests, Government of India to establish a National Centre for Sustainable Coastal Management at Anna University, Chennai, 21 June 2010.

The Memorandum of Understanding was signed by Prof. Mannar Jawahar, Vice Chancellor, Anna University Chennai and Shri. J.M. Mauskar, IAS, Additional Secretary, Ministry of Environment and Forests in the presence of Prof. K. Kasturirangan, Prof M.S. Swaminathan and the others on the dais.

In this event the Anna University Declaration was also signed by NCSCM and all its consortium institutions along the coast of India.

Inauguration of National Centre for Sustainable Coastal Management (NCSCM) at Koodal Building, Anna University, Chennai, 25 Feb 2011.

The National Centre for Sustainable Coastal Management was inaugurated on 25 Feb 2011 by Prof. Dr. P. Mannar Jawahar, Vice Chancellor, Anna University, Chennai and Shri. J. M. Mauskar, IAS, Special Secretary, Ministry of Environment and Forests, Government of India, New Delhi.

Workshop to ensure Fish workers participation in the implementation of CRZ 2011

13-14 June 2011

Koodal Hall, Anna University, Chennai.

As an initiative to involve fisher folk in the implementation of CRZ 2011, the Society of Integrated Coastal Management (SICOM) in association with the National Centre for Sustainable Coastal Management (NCSCM), is conducting a two-day workshop on "Initiatives of fishermen participation in the implementation of CRZ 2011". Five participants from each coastal state belonging to coastal civil society, fishermen and NGOs are invited to participate in the workshop

Workshop on Coastal Wellbeing Methods

14 - 18 November 2011

Koodal Hall, Anna University, Chennai

The first workshop organized by NCSCM, which had a regional level focus (Tamil Nadu, India), was aimed at facilitating agreement among the project participants about the mode for proceeding and the project direction. The key concepts of 'wellbeing' and 'interactive governance' were introduced and opportunities presented by the United Kingdom Ecosystem Services and Poverty Alleviation (ESPA) programme were discussed. An outcome of the workshop was the adoption of a working goal that would inform subsequent ESPA research activities as, **"to improve the wellbeing of poor people in fisheries in South Asia in a way that is positive for ecosystem conservation, through the improvement of systems of governance"**

National workshop on Integrated Coastal Zone Management project (ICZM) planning

16-17 March 2012

Bhubaneswar, Odisha

National Centre for Sustainable Coastal Management (NCSCM) collaborated with Integrated Coastal Zone Management Project (ICZMP) in Odisha, State Project Management Unit to organize a two days national workshop on "ICZM Planning" under the aegis of the World Bank assisted Integrated Coastal Zone Management (ICZM) Project. Representatives from almost all the coastal states of the country including Andaman & Nicobar Islands attended the workshop to prepare a long term ICZM Planning for their respective states. The two day workshop was inaugurated by Sri Debi Prasad Mishra, Hon'ble Forest & Environment Minister, Govt of Odisha at Hotel New Marrion, Bhubaneswar.

Brain Storming Session on Marine Biodiversity - COP 11

5 September 2012.

Hyderabad

NCSCM hosted a side event during the COP 11 at Hyderabad with special emphasis on **Lagoons, Lives & Livelihoods - Bridging people and environment through science - policy**. It was envisaged to comprehend significant interrelationships between lagoon ecosystem biodiversity and the socio-economic development of the local communities, explore role of science and technology in conservation and management and biodiversity conservation using traditional knowledge and management systems. Three diverse case studies that combine traditional knowledge, degree of community participation in management and conservation measures to maintain ecological integrity were highlighted. Further success stories from Chilika and Pulicat Lagoons of mainland India and the Lakshadweep Islands indicating community's response to manage these lagoons effectively were projected.

A special publication on, “Lagoons, Lives and Livelihoods” was published in commemoration of the event.

Delineation of Primary and sub cells for Orissa Coast at Koodal building

27 & 28 December 2012

Koodal Building, Anna University, Chennai

A framework for delineating of Shoreline Management Units for Odisha Coast was developed based on classification of Coastal Sediment Cells such as Primary and Sub cells. The event was participated by Dr. Chandra Mohan, Indomer and Dr. M. Baba, Former Director, CESS, Trivandrum.

Erosion Mapping for Hazard Line Mapping

08 January 2013

Koodal Building, Anna University, Chennai

The meeting was organized with the specific objective of forming teams, distribution of responsibilities and resources between the partner organizations and preparation of detailed implementation and review plan for the project. The scientists from NCSCM and Survey of India (Mr. M. Dharmaraj, ICZM, Project Director, Mr. S.K. Sinha, Director, Sol and Mr. B.C. Parida, Director, Sol, Chennai) participated in the meeting.

Workshop on Coastal Ecosystem health Report card of Chilika Lake

04-07 Feb 2013

Chilika Development Authority, Bhubaneswar

National Centre for Sustainable Coastal Management (NCSCM) Ministry of Environment and Forests, Government of India in collaboration with, Chilika Development Authority (CDA), Bhubaneswar organized an in International Workshop to develop a scientifically robust "Ecosystem Health Report Card for Chilika Lake" to assess the health of the Chilika lake and suggest possible management response.

The workshop was attended by scientists from Chilika Development Authority, National Centre for Sustainable Coastal Management (NCSCM), State Project Management Units of Gujarat and West Bengal, Indian Nitrogen Group, Gujarat Ecological Education and Research Foundation, Center for Environmental Science, University of Maryland, USA, United Nations Environment Programme (UNEP), FAO and Bay of Bengal Large Marine Ecosystem (BOBLME) project.

The participants reached consensus on the indicators (e.g., water quality, fisheries, biodiversity etc.) which are critical for the health of the Chilika lake ecosystem and also decided on the threshold values of each parameter. This will be fine-tuned further through a stakeholders' consultation to check the validity of the proposed indicators and their threshold values as well as to ensure their engagement in the preparation of the ecosystem health report card which is not only important for Chilika Lake ecosystem health but also impacts their wellbeing.

The conceptual design of the ecosystem health report card was presented to Hon'ble Chief Minister Naveen Patnaik by a group of experts including Prof. R. Ramesh, Director, NCSCM, Dr. Ajit Pattnaik, CDA, Dr. Heath Kelsey of University of Maryland, USA and Dr. Anjan Datta of UNEP.

Interface Meeting with the Consortium Partners

25 Feb 2013

Koodal Building, Anna University, Chennai

The first meeting of the NCSCM–Consortium Institutions was held to present the research mandates of NCSCM and to review the research studies submitted by the Consortium members. The meeting was participated by twelve experts representing ten different consortium institutions and the members of the Project Technical Committee (PTC) constituted by MoEF

The NCSCM Team

Scientists

Ramesh, R
Director

Purvaja Ramachandran
Scientist - G Division Chair, FTR

Ramachandra Bhatta
Scientist - G Division Chair, ISE

Asir Ramesh
Scientist - E, ISE Division

Krishnan, P
Scientist - E, CMR Division

Rajkumari, S
Scientist - E, GEO Division

Sridhar, R
Scientist - E, IIM Division

Deepak Samuel V
Scientist - D, CMR Division

Gejo Anna
Scientist - D, GEO Division

Mary Divya Suganya
Scientist - C, GEO Division

Robin R S
Scientist - C, CMR Division

Sachithanandam, V
Scientist - C, IIM Division

Abhilash K R
Scientist - C, CMR Division

Sreeraj, CR
Scientist - C, IIM Division

Ganguly D
Scientist - C, FTR Division

Gurmeet Singh
Scientist - C, FTR Division

Muruganandham R
Scientist - C, GEO Division

Scientists

Priya, P
Scientist - B, ISE Division

Sarunji, K.J
Scientist - B, GEO Division

Madhumitha, R
Scientist - B, GEO Division

Deepika, R
Scientist - B, GEO Division

Mageswaran, T
Scientist - B, IIM Division

Manik Mahapatra
Scientist - B, IIM Division

Paneer Selvam, A
Scientist - B, FTR Division

Kakolee Banerjee
Scientist - B, FTR Division

Saravanan, U
Scientist - B, CIA Division

Sankar, R
Scientist - B, CIA Division

Shesdev Patro
Scientist - B, CMR Division

Margi Purohit
Scientist - B, CMR Division

Administration

Ananda Kumar K G
Manager - Admin/ HR

Alok Ranjan Samal
Manager - Finance/Accounts

N. C. Mittal & Co.
Chartered Accountants

INDEPENDENT AUDITOR'S REPORT

To

The Project Director,

National Centre for Sustainable Coastal Management

Chennai

Report on Financial Statements

We have audited the Financial Statements of National Centre for Sustainable Coastal Management (NCSCM), which comprises the Balance Sheet as at March 31, 2014, and Receipts & Payment Accounts for the period then ended, and a summary of significant accounting policies and other explanatory information.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial statements that give a true and fair view of the financial position, financial performance and cash flows of the Society in accordance with the Accounting Standards applicable and issued by the Institute of Chartered Accountants of India. The Society has prepared and maintained accounts in accordance with the Financial Manual adopted by the Society. This responsibility includes the design, implementation and maintenance of internal control relevant to the preparation and presentation of the financial statements that give a true and fair view and are free from material misstatement, whether due to fraud or error.

Auditor's Responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the Standards on Auditing issued by the Institute of Chartered Accountants of India. Those Standards require that we comply with ethical requirements and plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error. In making those risk assessments, the auditor considers internal control

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Firm's Website: http://ncmittalandco.com *Resourse Website*: www.auditfirm.net
Offices at: Chennai, Jaipur, Hissar, Kolkatta, Chandigarh, Rajkot, Bangalore, Dehradun, Faridabad and London (UK)

relevant to the Society's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates made by management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

Opinion

In our opinion and to the best of our information and according to the explanations given to us, the financial statements give the information required by the Act applicable in the manner so required and give a true and fair view in conformity with the accounting principles generally accepted in India:

a. *in the case of the Balance Sheet, of the state of affairs of the Company as at March 31, 2014;*

b. *in the case of the Receipts & Payments Account, of the cash flows for the year ended on that date.*

For N. C. Mittal & Co.
Chartered Accountants
FRN 000237N

(CA KARUNESH MITTAL)
PARTNER
M. NO. 095976

Place of Signature: Chennai
Date: 29-09-2014

FORM NO. 10B

[*See* rule 17B]

Audit report under section 12A(b) of the Income-tax Act, 1961, in the case of charitable or religious trusts or institutions

We have examined the balance sheet of **NATIONAL CENTER FOR SUSTAINABLE COASTAL MANAGEMENT** , **AABAN 2289A** [name and PAN of the trust or institution] as at **31/03/2014** and the Profit and loss account for the year ended on that date which are in agreement with the books of account maintained by the said trust or institution.

We have obtained all the information and explanations which to the best of **our** knowledge and belief were necessary for the purposes of the audit. In **our** opinion, proper books of account have been kept by the head office and the branches of the abovenamed **institution** visited by **us** so far as appears from **our** examination of the books, and proper Returns adequate for the purposes of audit have been received from branches not visited by **us** , subject to the comments given below:

NIL

In **our** opinion and to the best of **our** information, and according to information given to **us** , the said accounts give a true and fair view-

(i) in the case of the balance sheet, of the state of affairs of the above named **institution** as at **31/03/2014** and

(ii) in the case of the profit and loss account, of the profit or loss of its accounting year ending on **31/03/2014**

The prescribed particulars are annexed hereto.

Place **CHENNAI**
Date **29/09/2014**

Name	***KARUNESH MITTAL***
Membership Number	***095976***
FRN (Firm Registration Number)	***000237N***
Address	***NCMC HOUSE 730 SECTOR 30 FARIDABAD***

ANNEXURE

Statement of particulars

I. APPLICATION OF INCOME FOR CHARITABLE OR RELIGIOUS PURPOSES

1.		Amount of income of the previous year applied to charitable or religious purposes in India during that year (₹)	**149248548**
2.		Whether the **institution** has exercised the option under clause (2) of the Explanation to section 11(1) ? If so, the details of the amount of income deemed to have been applied to charitable or religious purposes in India during the previous year (₹)	**No**
3.		Amount of income **accumulated or set apart** for application to charitable or religious purposes, to the extent it does not exceed 15 per cent of the income derived from property held under trust **wholly** for such purposes. (₹)	**Yes** **180260**
4.		Amount of income eligible for exemption under section 11(1)(c) (Give details)	**No**
5.		Amount of income, in addition to the amount referred to in item 3 above, accumulated or set apart for specified purposes under section 11(2) (₹)	**0**
6.		Whether the amount of income mentioned in item 5 above has been invested or deposited in the manner laid down in section 11(2)(b) ? If so, the details thereof.	**Not Applicable**
7.		Whether any part of the income in respect of which an option was exercised under clause (2) of the Explanation to section 11(1) in any earlier year is deemed to be income of the previous year under section 11(1B) ? If so, the details thereof (₹)	**Not Applicable**
8.		Whether, during the previous year, any part of income accumulated or set apart for specified purposes under section 11(2) in any earlier year-	
	(a)	has been applied for purposes other than charitable or religious purposes or has ceased to be accumulated or set apart for application thereto, or	**No**
	(b)	has ceased to remain invested in any security referred to in section 11(2)(b)(i) or deposited in any account	**No**

		referred to in section 11(2)(b)(ii) or section 11(2)(b)(iii), or	
	(c)	has not been utilised for purposes for which it was accumulated or set apart during the period for which it was to be accumulated or set apart, or in the year immediately following the expiry thereof? If so, the details thereof	**No**

II. APPLICATION OR USE OF INCOME OR PROPERTY FOR THE BENEFIT OF PERSONS REFERRED TO IN SECTION 13(3)

1.	Whether any part of the income or property of the **institution** was lent, or continues to be lent, in the previous year to any person referred to in section 13(3) (hereinafter referred to in this Annexure as such person)? If so, give details of the amount, rate of interest charged and the nature of security, if any.	**No**
2.	Whether any land, building or other property of the **institution** was made, or continued to be made, available for the use of any such person during the previous year? If so, give details of the property and the amount of rent or compensation charged, if any.	**No**
3.	Whether any payment was made to any such person during the previous year by way of salary, allowance or otherwise? If so, give details	**Yes**

Details	Amount(₹)
DR. R RAMESH	**2107200**
DR R PURVAJA	**1209144**
DR. R BHATTA	**1558839**

4.	Whether the services of the **institution** were made available to any such person during the previous year? If so, give details thereof together with remuneration or compensation received, if any	**No**
5.	Whether any share, security or other property was purchased by or on behalf of the **institution** during the previous year from any such person? If so, give details thereof together with the consideration paid	**No**
6.	Whether any share, security or other property was sold by or on behalf of the **institution** during the previous year to any such person? If so, give details thereof together with the consideration received	**No**
7.	Whether any income or property of the **institution** was diverted during the previous year in favour of any such person? If so, give details thereof together with the amount of income or value of property so diverted	**No**
8.	Whether the income or property of the **institution** was used or applied during the previous year for the benefit of any such person in any other manner? If so, give details	**No**

III. INVESTMENTS HELD AT ANY TIME DURING THE PREVIOUS YEAR(S) IN CONCERNS IN WHICH PERSONS REFERRED TO IN SECTION 13(3) HAVE A SUBSTANTIAL INTEREST

S. No	Name and address of the concern	Where the concern is a company, number and class of shares held	Nominal value of the investment(₹)	Income from the investment(₹)	Whether the amount in col. 4 exceeded 5 per cent of the capital of the concern during the previous year-say, Yes/No
Total			**0**	**0**	

Place **CHENNAI**
Date **29/09/2014**

Name ***KARUNESH MITTAL***
Membership Number ***L 095976***
FRN (Firm Registration Number) ***000237N***
Address ***NCMC HOUSE 730 SECTOR 30 FARIDA BAD***

Form Filing Details	
Revision/Original	Original

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT
Annexure to the Balance Sheet as on March 31, 2014

ACCOUNTING POLICIES & NOTES TO ACCOUNTS

A **Significant Accounting Policies :**

1. Basis of Accounting:

a) The Society follows the cash basis system of accounting in the preparation of accounts.

b) The Company accounts are prepared under the historical cost convention and on the basis of a going concern.

2. Fixed Assets & Depreciation :

a) The society has no fixed assets as on date of the balance sheet. Fixed assets are stated at their original cost of acquisition inclusive of inward freight, duties & expenditure incurred in the acquisition, construction/installation including part of salaries and wages paid to own staff.

b) The assets transferred as grant in aid are written off as revenue expenses.

c) The depreciation is not charged on the fixed assets by the society.

d) The assets after being taken out of use are written off net of the sale value of the asset or scrap of asset from the books of accounts.

3. Current Assets And Loans & Advances:

In the opinion of the management, current assets, loans and advances as shown in the Balance Sheet have a value of realisation in the ordinary course of business at least equal to the amount at which they are stated.

B **Notes to Accounts**

Figure for the previous year have been regrouped and/or rearranged where necessary.

For National Centre for Sustainable Coastal Management

Director

National Centre for Sustainable Coastal Management
Ministry of Environment and Forests, Government of India
Koodal Building, Anna University Campus
Chennai - 600 025, India

As per the Audit Report of Even Date Attached
For N. C. Mittal & Co.
Chartered Accountants

(CA Karunesh Mittal)
Partner
Place: Chennai
Date: 29-09-2014

N.C. MITTAL & CO. INDIA FRN 000237N CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT

KOODAL BUILDING
ANNA UNIVERSITY CAMPUS,
GUINDY,
CHENNAI

Receipts & Payment Account

For the period ended on March 31, 2014

In Rupees

Receipts	Amount	Payment	Amount
Opening Balance		**Current Liabilities**	
Bank Accounts	*70,34,281.59*	*Car Advance*	*11,200.00*
Current Liabilities		*GIC*	*1,280.00*
Bid Security	*38,07,000.00*	*GPF*	*3,03,286.00*
Car Advance	*12,600.00*	*GPF Advance*	*91,200.00*
GIC	*1,440.00*	*GSLI*	*960.00*
GPF	*3,03,286.00*	*NPS*	*53,480.00*
GPF Advance	*1,02,600.00*	*PF*	*31,898.00*
GSLI	*1,080.00*	*Professional Tax*	*57,000.00*
NPMU - Fund Received	*6,76,96,668.37*	*Salary Payable*	*20,47,545.00*
NPS	*60,165.00*	*TDS Payable - Others*	*26,43,267.00*
PF	*63,796.00*	*TDS PAYABLE - STAFF*	*17,50,784.00*
Professional Tax	*1,25,015.00*	Performance Guarantee	*55,914.00*
Retention Money-Renaatus	*8,10,097.00*	**Fixed Assets**	
Salary Payable	*20,47,545.00*	*CIVIL WORKS*	*32,52,874.00*
TDS Payable - Others	*31,24,029.00*	*Furniture & Fittings*	*55,400.00*
TDS PAYABLE - STAFF	*20,67,944.00*	**Assets Under Construction**	*2,80,15,615.00*
WORKMAN COMPEN TAX	*2,70,032.00*	*INVESTMENT COST*	*1,33,51,443.00*
Performance Guarantee	*91,580.00*	Physical -Fixed Assets	*4,73,51,177.00*
GRANT RECEIVED	14,92,48,547.63	**Current Assets**	
Investments		*Consultancy Charges Paid*	*93,258.00*
FIXED DEPOSIT - UBI SHORT TERM	*3,50,00,000.00*	*SICOM- NEW DELHI*	*1,38,770.00*
Current Assets		ADVANCES	*48,13,826.00*
Consultancy Charges Paid	*93,258.00*	**Indirect Expenses**	
ADVANCES	*16,12,908.00*	**Capacity Building & Projects**	*14,55,338.79*
Indirect Incomes		Communication	*13,84,775.00*
Miscellaneous Income	*1,80,260.00*	**Hazard & ESA Mapping**	*7,40,00,000.00*
Indirect Expenses		Monitoring & Evaluation	*17,92,449.45*
Capacity Building & Projects	*30,578.00*	OPERATIONAL COST	*5,77,34,254.46*
Monitoring & Evaluation	*1,920.07*	Sedimental Cell Project	*44,83,562.00*
OPERATIONAL COST	*92,482.00*	**Closing Balance**	
		Bank Accounts	*2,89,08,555.96*
	27,38,79,112.66		27,38,79,112.66

Notes on Accounts & Accounting Policies are annexed to the Banlance Sheet

For National Centre for Sustainable Coastal Management

Director

Director
National Centre for Sustainable Coastal Management
Ministry of Environment and Forests, Government of India
Koodal Building, Anna University Campus
Chennai - 600 025, India

Place: Chennai
Date: 29-09-2014

As per the Audit Report of Even Date Attached
For N. C. Mittal & Co.
Chartered Accountants

(CA Karunesh Mittal)
(M. NO. 095976)
Partner

FRN 000237N

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT

KOODAL BUILDING
ANNA UNIVERSITY CAMPUS,
GUINDY,
CHENNAI

Income & Expenditure Account

As at March 31, 2014

(In Rupees)

Expenditure	Amount	Income	Amount
Expenditure		**Grant received**	**149248547.63**
Capacity Building & Projects	*2485533.79*	**Miscellaneous Income**	**180260.00**
Communication	*1384775.00*		
Hazard & ESA Mapping	*8817235.00*		
Monitoring & Evaluation	*1790529.38*		
OPERATIONAL COST	*52679495.46*		
Sedimental Cell Project	*4483562.00*		
Surplus transferred to Corpus Fund	7,77,87,677.00		
Total	**14,94,28,807.63**	**Total**	**14,94,28,807.63**

Notes on Accounts & Accounting Policies are annexed to the Income & Expenditure Account

For National Centre for Sustainable Coastal Management

Director

Director
National Centre for Sustainable Coastal Management
Ministry of Environment and Forests, Government of India
Koodal Building, Anna University Campus
Chennai - 600 025, India

Place: Chennai
Date: 29-09-2014

As per the Audit Report of Even Date Attached
For N. C. Mittal & Co.
Chartered Accountants

(CA Karunesh Mittal)
(M. NO. 095976)
Partner
FRN 000237N

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT

KOODAL BUILDING
ANNA UNIVERSITY CAMPUS,
GUINDY, CHENNAI

Balance Sheet

As at March 31, 2014

(In Rupees)

Liabilities	Amount	Assets	Amount
Corpus Fund	*11,63,97,408.00*	**Fixed Assets**	
Current Liabilities		*Assets Under Construction*	1,37,99,466.00
Performance Guarantee	*91,580.00*	*Computers & Systems*	*1,71,49,837.00*
Bid Security	*38,07,000.00*	*Equipment and Facilities*	*32,12,534.00*
Car Advance	*1,400.00*	*Goods & Equipment (Scientific)*	*5,38,71,516.00*
GIC	*160.00*	*GIS Software*	*1,92,83,151.00*
GPF Advance	*11,400.00*	*CIVIL WORKS*	*74,63,981.00*
GSLI	*120.00*	*Furniture & Fittings*	*5,26,957.00*
Society for Integrated Coastal Management	*12,46,75,035.96*	*Vehicle*	*9,09,706.00*
NPS	*6,685.00*	**Investments**	
PF	*31,898.00*	*FIXED DEPOSIT - UBI SHORT TERM*	*1,50,00,000.00*
Professional Tax	*68,015.00*	**Current Assets**	
Retention Money-Renaatus	*8,10,097.00*	Bank Accounts	
TDS Payable - Others	*4,80,762.00*	*UBI Current Account*	*2,77,67,229.96*
TDS PAYABLE - STAFF	*3,17,160.00*	*UBI SEDIMENT CELL SAVING A/C*	*11,41,326.00*
WORKMAN COMPEN TAX	*2,70,032.00*	Advances	
		ADVANCE TO NRSC, HYDERABAD	*6,51,82,765.00*
		ADVANCE TO CONTRACTOR	*1,45,14,000.00*
		ADVANCE TO OTHER INSTITUTIONS	*51,56,583.00*
		ADVANCE TO PARTNER INSTITUTIONS	*8,00,000.00*
		ADVANCE TO STAFF (LESS RECOVERIES)	*6,24,399.00*
		ADVANCE TO STAFF FOR TA	*4,26,532.00*
		Expenses Recoverable from SICOM	*1,38,770.00*
Total	**24,69,68,752.96**	**Total**	**24,69,68,752.96**

Notes on Accounts & Accounting Policies are annexed to the Banlance Sheet

For National Centre for Sustainable Coastal Management

Director

Director
National Centre for Sustainable Coastal Management
Ministry of Environment and Forests, Government of India
Koodal Building, Anna University Campus
Chennai - 600 025, India

Place: Chennai
Date: 29-09-2014

As per the Audit Report of Even Date Attached
For N. C. Mittal & Co.
Chartered Accountants

(CA Karunesh Mittal)
(M. No. 095976)
Partner
FRN 000237N

MITTAL & CO. FRN 000237N CHARTERED ACCOUNTANTS

NATIONAL CENTRE FOR SUSTAINABLE COASTAL MANAGEMENT
Ministry of Environment and Forests, Government of India

Anna University Campus, Chennai 600 025, India

www.ncscm.org