




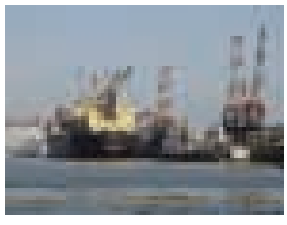


The Challenged Coast of India

TISS

NCPC
National Coastal Protection Campaign

PondyCAN!
Pondy Citizens' Action Network

BNHS

The Challenged Coast of India

A Report

An initiative of **NCPC**

Report prepared by **PondyCAN**

In collaboration with **BNHS & TISS**

Released on the occasion of

COP 11- Convention on Biological Diversity

Hyderabad – 8th to 19th Oct 2012

Ahana Lakshmi, Aurofilio Schiavina, Probir Banerjee, Ajit Reddy

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Dedicated to the Children of the World

We do not inherit the earth from our ancestors;

We borrow it from our children.

A Native American Proverb

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Foreword

To understand the ongoing destruction of the coast of India you only have to visit Puducherry. If you stand at the city's edge, looking out over the vast ocean, you will find the city misses something crucial – a beach. But what is even more important is the reason why the city has lost its natural treasure. In 1986 a harbour was built, stretching out to the ocean, blocking the movement of sand along the shoreline and taking away the beach. So, now the city has no sandy beach. It has only man-placed rocks to hold back the sea from taking away its land. A people have lost their playground. But more importantly a city has lost its critical ecosystem, which would protect its land and recharge its groundwater. Also, fishermen have lost their livelihood.

The fact is, Puducherry's harbour is small by any standards. And yet, it has the capacity to irrevocably change and destroy the coastline and affect the living ocean. "Beaches are rivers of sand," because each year waves transport huge quantities of sand from north to south and south to north. Beaches are living entities – winds and waves bring sand in one season and take it away in another. All interventions in this movement change the character of the coasts. Even groynes – built to protect the coast – stop the movement of sand; they destroy beaches, and without beaches to protect the land, during every monsoon the sea moves in and takes away more land. Erosion increases, and people lose homes. The answer then seems to be to build more seawalls and groynes – all adding up to more destruction.

It is this that we must begin to understand as India develops, indeed over-develops, without thought or foresight, along its last frontier.

We know today that development is imploding along the coasts of this country. The growth logic is apparent – for instance, thermal power projects are sprouting along the coasts because these plants will burn imported coal, and so building infrastructure on the coasts is cost effective. Furthermore, in many cases wetlands along the coast – marshy areas, tidal flats etc – are viewed as waste lands and are being handed over to industry. We forget that these 'wetland' areas have enormous value – for biodiversity; for flood mitigation and for local livelihood

We continue with these destructive practices also because we know so little about what is happening along our coasts. We know next to nothing about the projects – the numbers or their impacts – on the coasts, its ecology and its people. As a former member of a high-powered government committee on coastal matters, I found to my horror that we do not even have a count of the number of ports in India. The Central Government

knows only about “major” ports and leaves the rest of the business – permission to locate and build other ports – to State governments. There is no distinction between a major port and a non-major or intermediate port. It is just a matter of how many one can fit into the coast as fast and profitably as possible. Nobody, therefore, knows how many ports are being built. Nobody cares about the cumulative impact on rivers of sand.

It is time this is corrected.

This is why this report is so critical. It maps the projects, and this mapping presents to us the true picture of the scale of intervention on the coasts. This report will provide the way ahead. It will build our understanding of the impacts of these projects on ecology and people. It will help assess impacts of projects as single projects and assess cumulative impacts.

There is a pincer attack on our coasts. As a result, the Indian coast is doubly vulnerable today. On the one hand, it is facing unprecedented pressures because of industrial and urban development. On the other hand, it will see threats of climate-change-related devastations – from growing intensities of cyclonic storms to sea surges and eventual sea level rise. All this requires increased attention and vigilance for the protection of the coast and the people who live there. It is also clear that coastal areas are the habitats of fishing communities. These communities are today also in double danger – ironically from both conservation and development. Current conservation strategies have been exclusionary and do not account for their livelihood needs. Current development strategies have been destructive – taking away the little that fishing communities have in the name of progress and growth. It is for this reason that future policies for coastal area management must reverse these trends and find approaches to conserve and protect vulnerable ecosystems and secure the livelihood and habitats of its people. This is the challenge.

But as the authors of this report clearly point out, this challenge can only be met if we have a reformed and strengthened regulatory system for clearance of projects on the coasts. The current system under the Coastal Regulation Zone (CRZ) Notification is, to put it mildly, simply not working. It is non-transparent, unaccountable and unscientific. Worse, there is just no mechanism designed to ensure that the conditions set at the time of clearance are adhered to. There is no monitoring of projects, let alone assessment of the damage post-clearance. The system is not even designed to understand the cumulative impact of building projects along the coast – on people or ecology.

This has to be changed. It is time we took tough and informed decisions. This report, I believe, can be the game changer that we are looking for.

Sunita Narain
Centre for Science and Environment
New Delhi

Preface

People just love the beach, whether as a place to go when on holiday or for settling down. For us, having grown up in the coastal town of Pondicherry, the sand and the sea has been an intrinsic part of our lives.

About 20 years ago, this expansive sandy stretch started shrinking, and finally got engulfed by the sea. The lovely beach, our connection to the marine world, which we thought would forever remain our constant companion in times of fun and solitude, was gone. In its place now stands a monstrous rock wall dividing us from the Bay of Bengal. However, our loss of this recreational sanctuary might appear petty compared to the plight of entire communities of people who have lost their homes and livelihood. This has resulted in a major breakdown of their long-established traditional societal structures. Only later did we realize that this disaster was man-made. During meetings of the National Coastal Protection Campaign (NCPC), a coalition of organizations working on conservation and livelihoods along India's coast, we were shocked to learn how aggressive and insensitive development was turning our country's invaluable natural resources into biological and economic wastelands, and was having wide economic, social, cultural and ecological repercussions. NCPC then decided to put together all relevant information on the entire coast of India, on one platform, and make it accessible to everyone. This knowledge would be critical in engaging all stakeholders more actively and innovatively in its planning, protection and monitoring … a mammoth task undertaken for the first time.

COP11 – CBD presented us with the opportunity to initiate this long process of mapping, in partnership with Bombay Natural History Society (BNHS) and Tata Institute of Social Sciences (TISS). Given the time-frame of only 4 months, limited resources, and the colossal task of getting relevant and credible information for a coastline stretching for some 7,500 km, we decided to take up only the mainland and focus on a few parameters i.e. ports, harbours, coastal structures, power plants and Special Economic Zones (SEZs) to help us prepare:

a) an interactive web-based database consisting of geo-spatial mapping of ecologically sensitive areas, human settlements and infrastructure developments along the coast by way of crowd sourcing and using open source platforms and tools

b) a report, detailing each of these aspects at national and state levels, with maps, charts and tables to better understand the various scenarios.

The major outcome is an insight in macro perspective of hotspots where there are challenges of reconciling and prioritizing the development and conservation needs. This initiative demonstrates how digitized spatial

information can be generated and made accessible to all in a simple and cost effective way for planning and decision making.

The report gives policy makers, academicians, industrialists and civil society a glimpse of the wonder that is India's coast and the serious challenges it faces today. On one hand it will make them realize the vital role this beautiful coastline – which supports almost 30% of its human population – plays in India's economy by virtue of its resources, productive habitats and rich biodiversity, and on the other hand how degradation of the coastal environment has reached alarming proportions, closely reflecting the urban population explosion, rapid and unplanned urbanization, use of the ocean as a dump yard for industrial and toxic wastes, the taking over of large tracts of biodiversity-rich lands for development projects, and coastal erosion due to construction of seawalls and groynes. This report also triggers warnings that the coast needs urgent attention for the future sustainability of these coastal regions, on which our very well-being and survival depends. It calls for resolve and a long-term cooperative action of all stake holders.

The availability of insightful information is critical to good governance. Finally a beginning has been made in this regard, however imperfect it may be, and we hope that this will enthuse and motivate people to contribute by correcting, updating and expanding this information base. The journey has been fascinating; the writing of this report has connected us with wonderful people, and this has also helped us better understand our deep connection to our coastal environment. NCPC will continue to strive to build collaboration in fundamentally transforming the current development paradigm to one which results in dignity and justice for not only fellow humans but also for all other co-habitants of the coast and the coast itself.

Probir Banerjee
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Institutions & organisations
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* Salim Ali Centre for Ornithology and Natural History, Coimbatore – Information on Wetlands
* M S Swaminathan Research Foundation, Chennai – Information on Mangroves
* Planet protect – Digitized maps of Marine Protected Areas in India
* Prayas Energy Group- Pune – Information on proposed Power Plants
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The Web 2.0, Quantum GIS, Bing, Google Earth, GeoDjango Inc. for having made a simple yet powerful tool like Google Earth available to all people; a tool which can empowers people to view, edit information to add their perspective of the world and obtain geo-spatial information at the click of a button making it possible to create what we call “sophisticated simplicity”.

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The Challenged Coast of India

Executive summary

Introduction

The coast is the interface between the sea and the land, a place that is constantly changing in time and space. Coastal areas also harbour a variety of ecosystems such as mangroves, coral reefs, seagrass beds, mudflats and sandy shores, where a variety of floral and faunal species abound. The coast is also very vulnerable to a variety of natural hazards such as cyclones and tsunamis. It is intact coastal ecosystems – dense mangrove forests, wide sandy shores, healthy coral reefs – that provide the buffer between elements of nature and human beings. People have always lived on or near the coast for the relatively equitable climate, apart from important coastal livelihoods such as fisheries and coastal agriculture.

Coastal areas have always played an important role in the socio-economic development of countries, primarily because seaborne trade remains the cheapest method of transporting large quantities of goods over long distances. Today's globalization requires movement of large quantities of raw materials and finished goods, and consequently there is strong emphasis on the development of ports and harbours. Concomitantly, the areas around the ports are also under development pressure – for industries, tourism and settlements. As more people migrate towards the coast, there is extensive change in land use and an increasing pressure on resources. Marshy areas and tidal flats are 'reclaimed', creeks are diverted, mangroves are felled, and in their place large industries and ports emerge, together with the various developments that go with them. The entire land-use pattern changes. From a natural landscape it becomes a mosaic of human activity. The natural ecosystems are put under stress and there is a breakdown or deterioration in ecosystem services as well as loss in biodiversity. Destruction of habitats has been reported as one of the top causes for loss of biodiversity, according to the Convention on Biological Diversity.

India's mainland coast of more than 6,000 km is a fraction of the world's coastline, but 17 per cent of the world's population (according to the 2011 census) lives in India. Of this, over a quarter live within fifty kilometres of the coast. On the Indian mainland, there are nine maritime states and two union territories with a coastline. There are 73 coastal districts (out of a total of 593). 77 cities and towns are located on the coast, including the urban agglomerations of Mumbai, Chennai, Kolkata and the rapidly expanding cities of Kochi and Visakhapatnam. India is also one of the mega-diversity countries with, among other ecosystems, extensive mangroves, seagrass beds and coral reefs along the coast.

Overall, the coast is under tremendous pressure – from both population and 'development'. However, there are no assessments available at the national level to provide estimates of the extent of the coast that is actually occupied by various human activities, and their possible impacts on coastal biodiversity.

COP 11 of the CBD in India

India hosted the 11th Conference of the Parties (COP) to the Convention in Hyderabad from 8th to 19th October 2012. One of the five issues communicated by the Indian Minister of Environment and Forests (MoEF) as an agenda for the inter-ministerial meeting was coastal and marine biodiversity. 'The Indian NGO Forum for CBD' (INFC) comprising NGOs and civil society representatives working on biodiversity issues and aspects was intended to take Indian conservation concerns and people's issues to the CBD COP 11 and MOP 6 with the Bombay Natural History Society (BNHS) as the nodal agency in India facilitating the Global NGO Alliance on the CBD at COP 11. As part of the activities of the National Coastal Protection Campaign (NCPC) for the CBD COP 11, **PondyCAN** (Pondy Citizens' Action Network) along with **TISS** (Tata Institute of Social Sciences) **with funding support from BNHS** took up the responsibility of preparing the position paper for **Coastal Area Management in India**. This exercise was to provide hard details at a national level to show that India's coastal areas have rich and diverse eco-systems and are densely populated by settlements. Rapid expansion of commercial activities along the coast and large developments like ports and power plants, which spawn associated industries, are consuming large areas of the coast as well as having adverse impacts on biodiversity and livelihoods.

The study

India has the Coastal Regulation Zone Notification issued under the Environment (Protection) Act, 1986. The notification (first issued in 1991, reissued in 2011) designates a distance of 500 metres landward from the high tide line as the Coastal Regulation Zone (CRZ), where activities are restricted (those that do not require waterfront are largely prohibited). As part of the CRZ Notification, each coastal state was to prepare a Coastal Zone Management Plan (CZMP), by which exercise the different CRZ categories and sub categories would be mapped. However, the high tide line has not been uniformly delineated along the coast. The non-availability of the CZMP maps, the lack of comprehensive and cohesive information regarding development activities, and the difficulties in accessing information in digital form, which makes map overlays impossible, makes it difficult for civil society as well as the primary stakeholders to take informed decisions about large scale activities being planned in coastal areas.

Towards building up a comprehensive database, an exploratory assessment of the extent of coastal development activities that have taken place on the coast of India was conducted by collecting geo-spatial information from a "virtual" survey of the entire coastline of mainland India, using "Google Earth" maps and other geo-spatial navigation tools, as well as from available literature. Secondary information collected from various sources has been used to validate as well as derive an understanding of both the physical and ecological impact of these structures.

The main activities of this study were:

- to use geo-spatial data to identify, enumerate and map coastal structures like seawalls, groynes and jetties to view the physical impact of these structures on the coast;
- to identify, enumerate and map current and proposed ports, power-plants and commercial activities and developments such as special economic zones along the coast;
- identify, enumerate and map coastal settlements;
- enumerate and map water bodies situated along the coast
- to assess the likely impacts of infrastructure projects on biodiversity along the coast;
- to assess the likely possible impacts of infrastructure projects on livelihoods of communities dependent on coastal and maritime ecosystems;
- to outline a framework that can ensure the minimization of biodiversity and livelihood losses along the coast of India; and
- to implement methodologies that can be replicated with low budgets and minimal skills so that the maximum number of people can adopt them.

A major issue faced during the survey was the definition of the Indian coastline. As it is impossible to measure the exact length of a coastline, for this study's survey we have measured the length of the path along the

coastline that we have followed in “Google Earth” during our survey, at a scale at which the features that we were looking for (structures, settlements, water bodies, etc.) were visible and measured during the data collection. The length of this path, which is about 6,700 km long, is therefore for practical purposes referred to as the length of the coastline that we have surveyed. It was found to be barely 15% more than the one provided by NATMO (National Atlas and Thematic Mapping Organization), the major differences occurring in the states of Gujarat, Maharashtra and West Bengal, which have the most non-linear parts of the coastline.

Coastal biodiversity

Major ecosystems include mangroves, mudflats, salt marshes, coral reefs, seagrass beds, estuaries and lagoons, all of which are highly productive and support extensive fisheries and associated livelihoods. Coastal wetlands, among the most productive of ecosystems, have been mapped by the Space Application Centre as covering 40,230 km^2. Probably only about a third of India’s coastal habitats have been surveyed for biodiversity, with mostly commercially important fin fish and shellfish, corals, larger reptiles and mammals inventoried. Mangroves of the Sunderbans of West Bengal, Coringa in Andhra Pradesh and Bhitarkanika in Odisha are well known. The coastal lagoons of Chilika, Pulicat and Vembanad as well as the Rann of Kachchh are important stop-over points for migratory birds. While some areas and specific species have been given various forms/levels of protection under Indian laws, physical alteration and destruction of habitats, especially of mangroves and mudflats, is a major threat to biodiversity. In this study, 17 protected areas were mapped along the coast, covering a length of 647.46 km, about 10% of the coastline.

Coastal settlements

India has a large number of coastal cities, including the two megacities of Mumbai and Kolkata. Other large cities on the coast include Chennai, Tuticorin, Cuddalore, Visakhapatnam and Puducherry on the east coast, and Kochi, Mangalore and Surat on the west coast. Many of the port cities are also becoming industrial hubs and changing into urban agglomerations. There are a number of smaller towns and villages located along the coast with populations largely dependent on agriculture and fishing, but in many places industrial development is swallowing agricultural lands. This study found about 1,260 settlements along the coast occupying 1,411 km, or more than 21% of the coastline.

Marine fishing communities live close to the shoreline and form a sizeable population. While most states have permanent settlements of marine fishers, there are places where seasonal migration takes place when the fishing communities camp in temporary shelters. The Central Marine Fisheries Research Institute’s census of 2010 estimates that the marine fishing community consists of 42,53,451 people in 9,18,340 families living in 3,288 villages across the 9 states and 2 union territories of the mainland. Of these, 90% belong to traditional fisher families. Odisha has the maximum number of settlements (813) followed by Tamil Nadu (573). Tamil Nadu has the largest population of marine fishers (8 lakhs), followed by West Bengal (6.4 lakhs) and Kerala (6.1 lakhs).

Coastal activities

Fishing is an important activity, with 1,511 marine fish landing centres and dedicated fishing ports. About 38% of the marine fisherfolk are engaged in active fishing, 85% of them working full time. Most of the fishing continues to be small scale/artisanal, though in recent times close to 70% of the catch is brought in by mechanized boats that provide employment to only 34% of the fishers. The estimated marine fish landing of India during 2010 was about 3 million tonnes. Sea salt manufacture is carried out in certain areas. Gujarat is the highest producer of sea salt in India, followed by Tamil Nadu. Coastal aquaculture, though a traditional activity, was limited to certain areas till the early 1990s. Extensively practiced today along the coast, the rapid growth has been at considerable environmental cost, with shrimp aquaculture farms being held responsible for destroying mangroves, increasing salinization of water, pollution and land degradation. Tourism – religious, cultural and recreational – is extensive, with a large number of religious shrines located in coastal towns/villages that attract pilgrims from all over. In recent times, recreational tourism, especially in sandy beach areas, has been steadily growing, with coastal resorts and hotels mushrooming all along the coast, but also causing, in many places, problems due to reduced/restricted access to beaches.

Large scale development activities since India's Independence have resulted in a proliferation of industries, mostly located near the major ports. In recent decades, to attract private investment in industry and allied activities, a number of notified ports have been privatized and expanded to handle the huge goods traffic, especially of raw materials such as ores. About 150 ports were identified, enumerated and mapped in the study, and while the area occupied by them in the 500 m zone may appear to be small, their actual area of impact may extend far beyond the immediate port area. In fact, for planning purposes the area of impact of a port can be considered to be at least 20 km more than the land a port occupies along the coast. The area of impact of all ports along the coastline is therefore estimated to now occupy approximately 3,000 km or approximately 45% of India's coastline.

Port-based and port-associated zones for manufacturing and processing have also grown in number and extent, called by various names such as special economic zones (SEZs) or special investment regions (SIRs). Land for most of these activities is being allocated/acquired by the government, especially in the case of public-private partnerships. There have been a number of cases where community lands have been incorrectly designated as wastelands and allocated to private industrial entities at low prices. To provide energy for the vast development activities that are being planned, the coast is also going to be dotted with thermal (mostly coal-based) power plants. The coast is the preferred location because of the availability of sea water that can be used for cooling, and because each power plant is planning a captive jetty of its own to enable direct feeding of imported coal to fuel the power plant. This study found 27 existing power plants with 59 more in the offing.

Many of these development activities have, apart from extensive change in the land use of the area, adversely impacted the shoreline. The breakwaters and other structures constructed for ports and harbours have resulted in the interception of the littoral drift, and the result has been down-drift erosion. Sand mining in rivers as well as along the beaches, a lot of it illegal and in response to the burgeoning demands of the construction industry, as well as interception of sediment and water by upstream dams, has contributed to a sediment deficit in the coastal areas, resulting in coastal erosion.

Coastal structures

In 2004, an extent of 1,215 km of the 5,423 km coastline (as measured by the National Hydrographic Office - NHO) was affected by sea erosion. Now the extent has gone up to 1,624 km according to the latest information available with the CPDAC (part of which is yet to be updated). This shows up as an increase in the extent of erosion from 22% of the coast in 2004 to 30%. In other words, almost a third of the Indian coast is undergoing erosion. According to the CPDAC, 748 km of the coastline is currently protected; the protection is mainly localized, using RCC or rubble mounded seawalls, though in recent years attempts have been made to use geotubes. In this study, 517 km of seawalls were measured. Not surprisingly, Kerala – which has 80% of its coast as sandy beaches and reportedly the maximum extent of erosion – was found to have 216 km of seawalls, followed by Gujarat with 118 km of seawalls. In both cases, sand mining is supposed to be a major cause for coastal erosion. An earlier study by the Ministry of Earth Sciences (MES) has implicated ports (specifically port-related structures such as breakwaters) in coastal erosion, especially along the east coast.

Of the 1,040 structures in the littoral zone mapped in the study, about 480 are seawalls, about 180 are groynes and about 130 are breakwaters. Groyne fields are being increasingly promoted as the solution to coastal erosion, often as alternatives to seawalls – which prevent access to the shore, vital for fishers. However, groynes need not necessarily promote the growth of beaches, as was shown by a case study where the extent of beach gained was found to be only a fraction of the area lost.

Findings

A clear conclusion that can be drawn from this study is that India's coastal areas (and hence the biodiversity that they contain) are challenged, due to very aggressive development – present and planned (Ref. chapter 8, Fig. 8.8) and the indiscriminate construction of coastal structures. Settlements, commercial areas, ports and waterbodies already occupy over 43% of the coast. This does not include CRZ-I areas such as turtle nesting sites or sandy beaches and other ecologically important areas. It is not just biodiversity that is being compromised but also the livelihoods of millions who depend on primary resources from coastal areas, especially the coastal wetlands, apart from displacement due to land acquisition and alienation from their traditional livelihoods. Unfortunately,

in spite of all the laws and guidelines, coastal degradation has reached alarming proportions. To implement all the proposals of various ministries a coastline many times longer than what is actually available will be needed!

There is an urgent need to rationalize development if we are serious about conserving the coastal ecosystems and biodiversity and ensuring that the coastal communities are not displaced or affected. The first step in this age of technology and reforms will be to ensure relevant information at a national scale is available in a user-friendly way so that coastal governance is transparent and accountable.

Recommendations

Based on the above observations on the coast, home to a wealth of natural resources, and the pace at which it is being destroyed due to systemic problems, the following recommendations should be considered if India is serious about protecting its natural assets and the livelihoods of coastal communities. The Ministry of Environment and Forests (MoEF), with a view to making coastal governance transparent and accountable, should:

1. **Policy:** Draft a coastal policy, considering the length of India's coastline, for conservation of biodiversity in the planning stage, not at individual project level, to safeguard the rich natural resources of the country.
2. **Planning:** Mainstream in all planning processes – an integrated approach taking into account the environmental and social concerns, the concept of national and regional planning based on comprehensive information, the carrying capacity, cumulative impact and precautionary principles, and the commitments made by India to itself and the international community – instead of putting the MoEF in a quandary as to whether to give approval after all aspects of the project have already been finalized, and in some cases the work has even started.
3. **Coordination:** Play a proactive role in implementing the Environment (Protection) Act by establishing an inter-ministerial coordination committee during the planning process, both at the Central and State levels, and making environmental aspects the base layer of any planning exercise.
4. **Capacity building:** Strengthen environmental governance with adequate human and financial resources for monitoring and enforcement, in keeping with the number of projects sanctioned, as currently there is insufficient capacity and accountability of those dealing with governance of the coast.
5. **Civil society participation:**

   a) Engage the local community in the decision making process at the inception stage of the project to make development inclusive and harmonious.

   b) Include independent specialists known for their integrity from civil society, and representation from fishing communities at all levels, in the CRZ and infrastructural committees to explain the ground realities.
6. **Assessment of damage:** Conduct at the earliest a detailed assessment of existing projects, which takes into account environmental, social and economic impacts, cumulative impacts and habitat loss, mitigation costs and current efficiency, with possibilities for upgradation.
7. **Environmental Impact Assessment (EIA):**

   a) Review the EIA process for coastal projects to improve the Terms of Reference for marine and coastal EIAs.

   b) Make the EIAs independent of project proponent and to be commissioned by MoEF. While the current requirement of the MoEF towards insisting on NABET (National Accreditation Board for Education & Training) certification of EIA consultants is a step in the right direction towards improving quality of EIAs, the team evaluating the final EIA needs to be knowledgeable and unbiased.

8. **CRZ 2011:**

   a) To remove from CRZ 2011 the various exemptions that go against the principles of CRZ, and add provisions which are already enshrined in the EIA 2006 but not being implemented; to put stress on cumulative impacts, carrying capacity and precautionary principles. Tools for some of these, currently weak, must be strengthened.

   b) Elevate the CRZ notification to the status of a subordinate legislation under the EPA.

   c) To implement the provisions of CRZ 2011 that seek strict action on past violations of CRZ 1991, and stoppage of all untreated effluents being dumped in the sea.

9. **Information dissemination:** To make available in the public domain and on a single platform, in a digitized format, all the relevant and comprehensive information on projects, including detailed maps, for better public involvement and assessment of projects.

Information is critical for all dimensions of good governance. This exploratory survey has used widely available satellite imagery to come up with an assessment that gives the extent of coastal development at the national level, as well as for every maritime state in India. If such a study by a small group in a short time using simple research tools can come up with a detailed assessment, it should be possible for larger institutions with not only access to requisite funds but also to all information in the digital format to make much more detailed assessments that would really show where and how the coast is challenged and identify what are the specific mitigation and restoration measures required.

Collaboration between government agencies, academic institutions, organizations and individuals can fundamentally transform the current development paradigm to one which results in happiness and well-being of all people by actively fostering dignity and justice.

An Appeal

This report is the first step in a long journey to protect and consolidate the beautiful coastline of India for present and future generations, not just as the meeting point between the land and the sea but more importantly, the rich environmental, sociological, economic and cultural heritage that it sustains. If this report catches your attention and inspires you to join us in our journey, there are a number of ways in which you could help in shaping it.

- **Join NCPC our umbrella organisation**: strengthen our foundation by the widest possible involvement of communities and organisations
- **Contribute to the knowledge base**: share any relevant data that you may already have and incorporate our data collection objectives into your future projects
- **Help our funds grow**: support targeted projects which will further the objectives and recommendations set out in this book
- **Follow the development**: visit our website www.thechallengedcoastofindia.in for updates

You can contact us at thechallengedcoastofindia@gmail.com

1. Introduction: setting the scene

This we know... the earth does not belong to man, man belongs to earth.
All things are connected, like blood which connects one family.
Whatever befalls the earth befalls the children of the earth.
Man did not weave the web of life - he is merely a strand in it.
Whatever he does to the web, he does to himself.
- Chief Seattle, 1854

1.1. Prologue

Standing on the soft sand of the beach, you face the sea and look at the waves swelling, rolling and breaking. In the distance, you can see the outline of ships standing in a line. An occasional boat may bob in the waves, appearing and disappearing. Behind you, a stretch of sand, and then the road, traffic, buildings and civilization. At this point, they do not matter too much, for your ears are filled with the sound of the sea. You wait in anticipation as the foamy waters move towards your feet and swiftly encircle them. You feel your feet sinking down, a small pull towards the sea as the waters drain back. The next wave is now on its way. A little smaller than the previous one, so you draw forward. A few metres away, the waves are reaching a little further inland. The line of the tide is marked by the tell-tale line of white shells and slightly larger sand grains. You look down and see tiny holes unblocked, and crabs scuttling around making a quick dash to see what morsels they can grab and then run into their underground homes before the next wave rolls forward. A refreshing breeze on the hottest of days draws you to the beach even when the sun is at its highest.

This is the way of the interface between the sea and the land, a space that is constantly changing in time and space. Sometimes the sea rolls forward threateningly when the large waves are pushed further inland by a cyclone or a tsunami. At other times the sea is calm, there is barely a ripple, and the waves just swell and slide rather than crash. Not too far away is a river mouth, an estuary or a creek. Perhaps once fringed with mangroves, it is now a bustling port with buildings and cranes dotting the skyline. A breakwater provides the tranquility for large ships to come close to land, discharge their cargo and load fresh cargo. On the beach are the catamarans and colourful fibre-glass boats, piles of nets and marine debris. A little beyond one can see the houses of the fishermen; maybe also a seawall to protect their homes from the sea that is now encroaching inland. A line of tall buildings has sprung up to maximize the ‘seaview’.

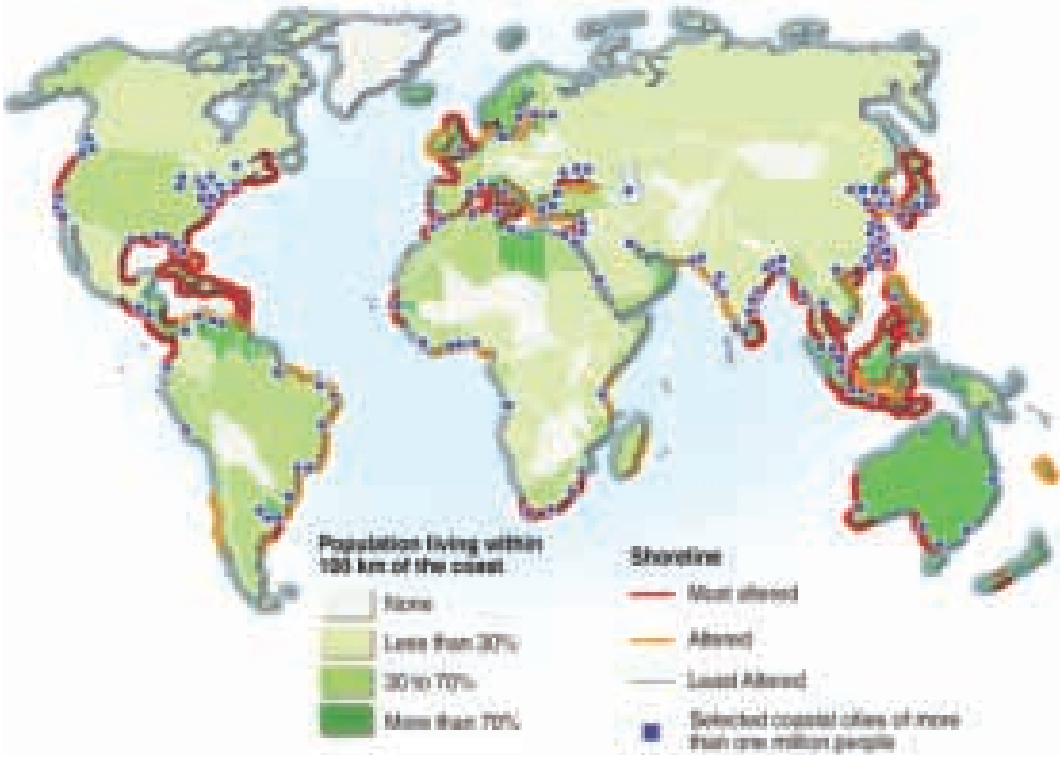
1.2. The coast

The coast is an area bordered by an ocean or a sea, dynamic and fragile at the same time. It is not sandy beaches everywhere – the geomorphology of the interface between the ocean and the land decides what kind of habitat is created. There are estuaries fringed with mangroves which are the abode of varieties of fish and shellfish; rocky shores with rocks covered with seaweed, molluscs; and sandy shores where turtles come to nest. There are coastal lagoons where waterbirds gather in the thousands, feeding on the soup of plankton and fish.

There are mud-flats that are used as staging posts by migratory birds on their way to their seasonal feeding or breeding grounds. There are huge deltas where the gushing waters of the rivers bring down sediment from hills that are being steadily worn down. The sediment content may be so large as to form a plume that is visible far out into the sea in satellite imagery. This sediment is what is picked up by the waves of the sea, and as they roll forward and back ruled by tides and currents, they transport it along the coast. The beaches expand and shrink as the seasons change. A creek is silted up, but the waters have to find a new place to flow out into the ocean, and a new mouth is formed. An old habitat is lost, a new one is formed. And the cycle of life goes on.

1.3. Altered coastlines – a global perspective

People have lived on the coast for thousands of years; today, an estimated 41 percent of the world's population lives within 100 km of the coast, and marine fisheries provide over 15 percent of the dietary intake of animal protein[1]. Traditionally, coastal areas have played an important role in the socio-economic development of a country, primarily because seaborne trade remains the cheapest method of transporting large quantities of goods over long distances. Pressure on the coast has been increasing since the dawn of civilization[2]. Many of the world's greatest or largest cities that have been known as centres of trade are located on the coast. But the vulnerability of the coast is well known too. The waves from the sea can wreak destruction as seen recently in the 2011 Japan tsunami and in the devastating 2004 Indian Ocean tsunami or the Paradip supercyclone of 1999, when huge waves from the sea flattened large areas on land. Since such events are nothing new on the coast, humans have intervened to protect their investments by building seawalls or dykes or breakwaters instead of allowing any natural evolution in the shoreline. Coastal marshes are filled up for development. A tidal inlet whose exchange point with the sea was changing has been 'stabilised' with a pair of trainer jetties to ensure that navigation is not interrupted. A coastal forest is steadily encroached upon and replaced by a concrete jungle, thus altering long stretches of the coastline[3,4]. One does not realize these impacts on a global scale unless one sees a bird's eye view of the world's coast (figure 1.1).



CREDIT: PHILIPPE REKACEWICZ, HUGO AHLENIUS, UNEP/GRID-ARENDAL

Figure 1.1: Coastal population and shoreline degradation[5]

1 Marine and Coastal Biodiversity.http://www.cbd.int/idb/2012/?ttl1#ttl1 accessed 1 August 2012.
2 Mee, L. 2012. Between the Devil and the Deep Blue Sea: The Coastal Zone in an Era of Globalisation. *Estuarine, Coastal and Shelf Science* 96(1):1–8. doi:10.1016/j.ecss.2010.02.013.
3 UNEP 2007.Global Environment Outlook GEO-4.http://www.unep.org/geo/geo4/media/
4 OSPAR Commission, 2009. Assessment of the impact of coastal defence structures. www.ospar.org
5 Coastal Population and Shoreline Degradation.http://grida.no/graphicslib/detail/coastal-population-and-altered-coastal-zones_d9f0# Accessed 20 July 2012.

While 'coast' can be simply defined as the area where land meets ocean, it is more appropriate to refer to a 'coastal zone'; its width varies from place to place depending on who is referring to it.

1.4. Valuing coastal ecosystems

The geomorphology of the coast decides the kinds of habitats and, accordingly, the biodiversity. From an ecological viewpoint, the interface between the sea and land, called the inter-tidal area, provides the greatest challenge to life. Organisms that live in this apparently harsh environment have to be able to survive in water whose salinity and temperatures change considerably and constantly. Take mangroves for example. They grow in a region of constantly shifting mud and silt brought in by rivers. To stabilize themselves, they have the most amazing root systems (in the form of prop roots, buttress roots and pneumatophores) that stand firm whether it is the fine shifting silt from the rivers or the strong waves of the sea. In turn they provide a variety of niches for animals, such as spawning grounds for fish and prawn, mudskippers and crabs, which in turn are the economic backbone of coastal fishers. On the treetops are birds – ibis and storks, pelicans and egrets, and many more. As the tide surges in, larger fish and even mammals such as dolphins come in search of prey, and retreat back into the sea as the tide goes out. Fishermen glide through the channels filling their baskets with fish and crabs that live in the mangrove ecosystem, or set up stake-nets in the channels to trap the fish and shellfish that are brought in by the tide. The story is similar with other coastal ecosystems, especially with lagoons and other wetlands.

Traditionally, coastal fishers have a deep understanding of the importance of resource conservation. This is why, for example, coastal communities developed customary laws for protecting such areas from degradation through closed seasons or no-take areas. Those who live in close proximity to the sea know the protective value of sand dunes. Unfortunately, these may add up to only a small proportion of those who receive the benefits of nature indirectly, and therefore the latter are less able to comprehend the importance of protecting them. Many of the products and services provided by ecosystems are not traded. To most, it is the individual species – tuna or

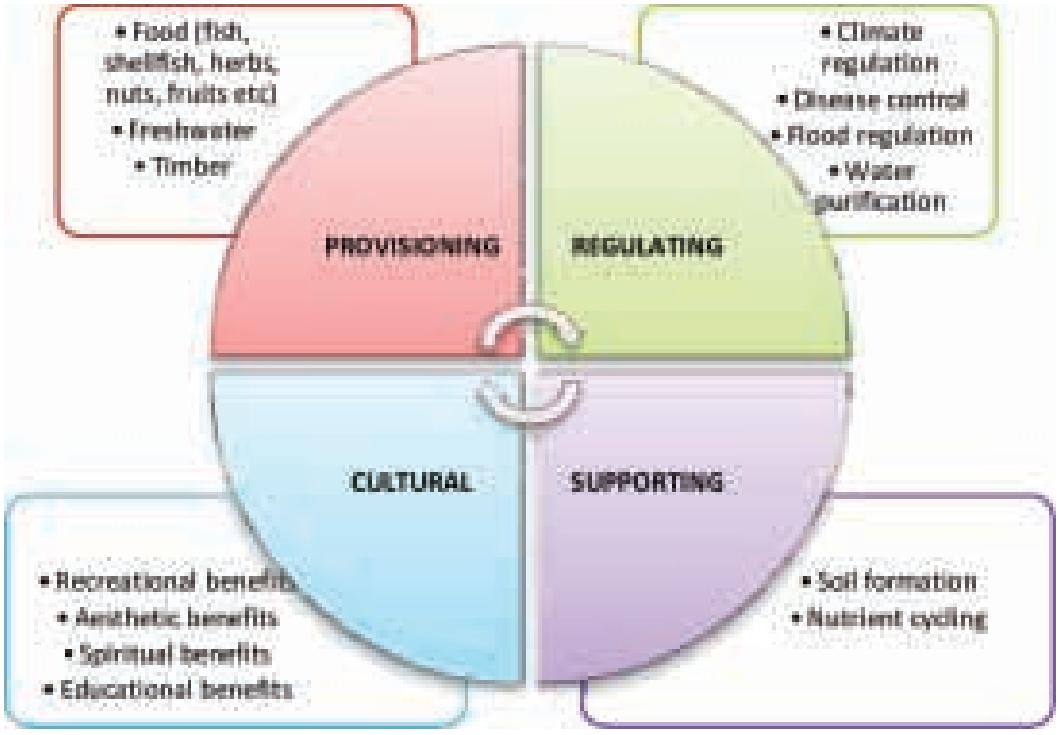


Figure 1.2: Ecosystem services – some examples

eels or oysters – that were (and are) important and not their habitat, the coastal waters, sandy bottoms or the rocky shore. It was only after the Millennium Ecosystem Assessment (MEA)[6] that the importance of entire ecosystems became codified and clarified as 'ecosystem services'.

The MEA also pointed out that nearly 60% of the ecosystems surveyed were being degraded or used unsustainably.

6 Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-Being: Current State and Trends: Findings of the Condition and Trends Working Group (Island, Washington, DC).

Thus, the new approach of ecosystem management of natural systems was evolved, which emphasizes that it is the habitat that has to be conserved and protected and not just individual species, though they too are important.

It is not enough to say that ecosystems provide a variety of services that are essential for human survival. In a predominantly consumer-driven capitalistic world, it is also essential to be able to 'value' such services in economic terms by specifying use and non-use values and then quantifying them (Figure 1.3)[7]. This is one of the most challenging exercises of growing importance today[8].

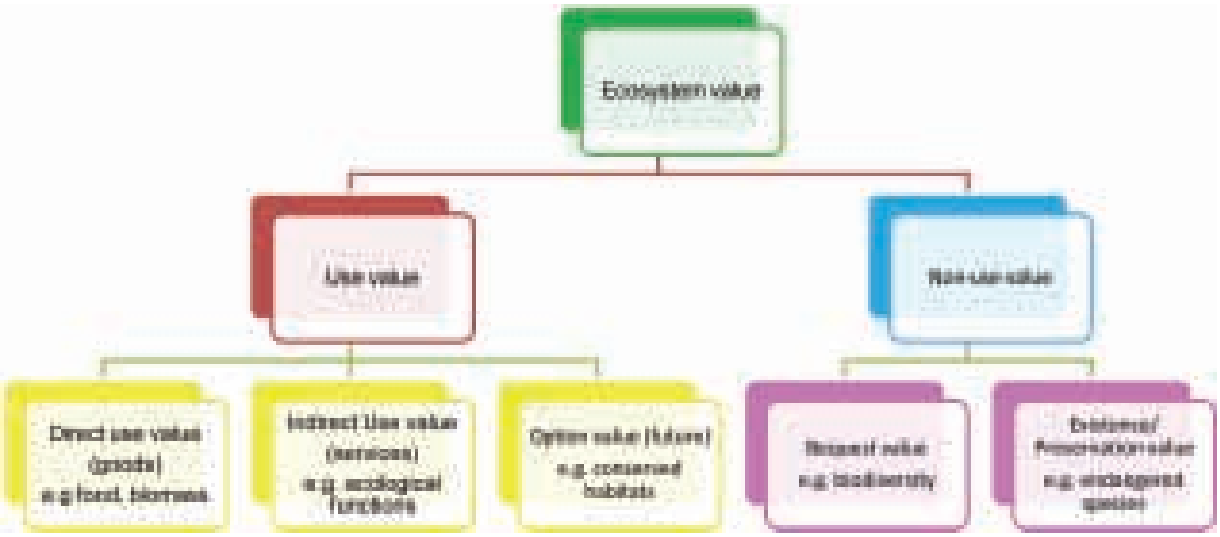


Figure 1.3: Total economic value of coastal resources

1.5. Drivers of biodiversity loss on the coast

Coastal ecosystems are reportedly the most productive, mainly because of the nutrient inputs received from the land. Important coastal ecosystems include estuaries, coastal lagoons, mangrove forests, coral reefs, near shore areas – including inter-tidal areas – and seagrass beds. The census of marine life, which has taken on the systematic documentation of life in the oceans, reported in 2010 that it had encountered life everywhere, upping the estimate of known marine species to nearly 250,000, though it is probably a fraction of the actual biodiversity[9]. However, the story from around the world is the extensive degradation of habitats and loss of biodiversity. The extinction rate of species caused by humans far outnumbers the natural (background) extinction rates. This degradation has accelerated significantly in the last few decades thanks to technological advances, such as larger and more powerful fishing fleets, accurate location of shoals using sonar, etc, and allowing larger catches that place considerable strains on sustainability of fish stocks. The range of the fishing fleets allows people to fish far away from their home base, in places where they lack the local knowledge of sustainable yields that had been developed and understood over centuries, with the result of rapidly emptying seas.

According to the **Convention on Biological Diversity (CBD)**, the five principal pressures driving biodiversity loss are habitat change, over-exploitation, pollution, invasive alien species and climate change[10]. At a 2011 workshop held at the University of Oxford, England, world experts on the ocean who met concluded that "…not only are we already experiencing severe declines in many species to the point of commercial extinction in some cases, and an unparalleled rate of regional extinctions of habitat types (e.g. mangroves and seagrass meadows), but we now face losing marine species and entire marine ecosystems, such as coral reefs, within a single generation. Unless action is taken now, the consequences of our activities are at a high risk of causing, through the combined effects of climate change, over-exploitation, pollution and habitat loss, the next globally significant extinction event in the ocean"[11]. Among other actions, the conference recommended that urgent actions be

7 IUCN, 2007.Valuing coastal ecosystems. Coastal Ecosystems Issue #4, April 2007.

8 The economics of ecosystems and biodiversity.www.teebweb.org

9 Census of Marine Life.www.coml.org and Ocean Biogeographic Information System www.obis.org

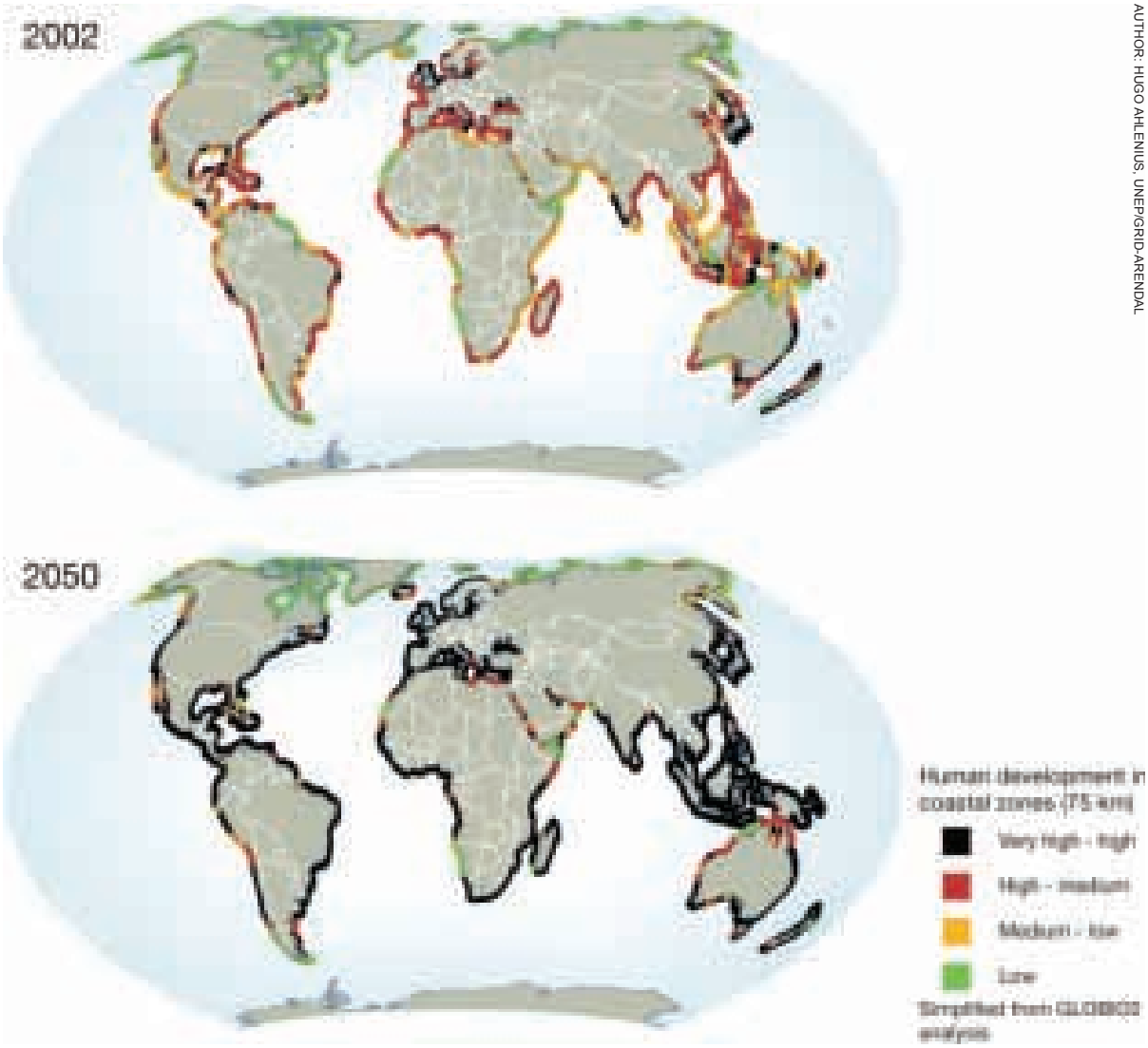
10 CBD (2010).Global Biodiversity Outlook 3.Secretariat of the Convention on Biological Diversity. Montréal.

11 Rogers, A.D. and D.d'A Laffoley,. 2011. International Earth system expert workshop on ocean stresses and impacts.Summary report.IPSO Oxford, 18 pp.

taken to restore the structure and function of marine ecosystems and proper and universal implementation of the precautionary principle.

This is not the first time that destruction of habitats has been raised as the most important problem area with respect to loss of biodiversity. **Physical Alteration and Destruction of Habitats** was identified as an area for priority attention by the UNEP in their GPA-LBA[12] project, focusing specifically on four economic sectors that potentially pose a threat to such habitats: tourism; ports and harbours; aquaculture; and mining (sand and aggregate extraction)[13].

All this brings home a number of questions – it is undeniable that habitats, especially coastal and marine habitats, have been degraded and what is remaining is facing considerable threat from 'developmental' activities. But what exactly is the extent of degradation, how is it happening and why? It appears that the impact of development is most severe around Europe, the east coast of the United States, east of China and in south-east Asia, as indicated in figure 1.4. As far as India is concerned, it shows that in 2002 the impact of human development on the west coast was high, whereas it was medium to high on the east coast; but by 2020, both the west and east coasts are going to be highly impacted by development.



AUTHOR: HUGO AHLENIUS, UNEP/GRID-ARENDAL

Figure 1.4: Human development in coastal zones[14]

12 GPA-LBA Global Program of Action for the Protection of the Marine Environment from Land Based Activities. www.gpa.unep.org

13 Stakeholder Forum and GPA. 2006. Physical Alteration and Destruction of Habitat A background for the GPA Online Dialogue. http://www.stakeholderforum.org/fileadmin/files/Physical_Alteration_and_Destruction_of_Habitat_Briefing.pdf

14 Human Development in Coastal Zones.http://maps.grida.no/go/graphic/human-impact-in-the-coastal-zones

1.6. Carrying capacity

The understanding that coastal zones have been extensively altered over time by anthropogenic activities, and such developmental pressures can and have resulted in adverse impacts on humans, is generally high, as indicated by the number of journal articles, books and media reports on the topic. This has led to increasing attention being paid to the concept of **carrying capacity** of the coast. In biology and ecology, the term 'carrying capacity of a species in an environment' refers to the maximum population size of the species that the environment can sustain indefinitely, given the food, habitat, water and other necessities available in that environment. This concept has been transferred from ecology and conservation biology and applied in various sectors from shipping to tourism. With coastal (especially beach) tourism high in the popularity list in most of the western countries, it is in this sector that the concept has been extensively applied in coastal areas, with reference to the number of people that a stretch of beach can handle without deterioration[15]. The World Tourism Organisation (WTO) has proposed that carrying capacity is 'the maximum number of people that may visit a tourist destination at the same time, without causing destruction of the physical, economic, socio-cultural environment and an unacceptable decrease in the quality of visitors' satisfaction'[16].

The importance of beach tourism and shorelines undergoing erosion has led to various shoreline protection mechanisms in terms of armouring the coast. Hard defence techniques, such as building seawalls, have been used since the 1800s, while soft defence techniques have been used since the 1900s. Beach nourishment, underwater sand nourishment and beach scraping were first used in the 1960s, and their use is increasing[17]. Hard coastal structures are known to have impacts on the shoreline. It is also known that the littoral zone in which such structures are located are likely to be high in biodiversity. Hence, there is an urgent need to take a holistic view of the various activities on the coast in terms of the carrying capacity. This is undoubtedly a difficult process because, 'Carrying capacities in nature are not fixed, static or simple relations. They are contingent on technology, preferences, and the structure of production and consumption. They are also contingent on the ever-changing state of interactions between the physical and biotic environment'[18].

The concept of carrying capacity has been used in India in a few places[19,20,21,22]. There appear to be no studies at either the regional or national level which have tried to assess if the cumulative impact of multiple activities has exceeded the carrying capacity of that area. This is a difficult task that requires the input and coordination of a huge amount of information. **As a first step, in this report, we focus on the extent of developmental activities in the coastal zone of India in order to be able to build a national perspective on coastal development and relate it to impacts on coastal resources (especially biodiversity) and coastal livelihoods.**

15 McCool, S.F. and D.W. Lime. 2001. Tourism Carrying Capacity: Tempting Fantasy or Useful Reality? Journal of Sustainable Tourism. Vol. 9, No. 5, 9:372-388.

16 Carrying Capacity Assessment for tourism development. Coastal Area Management Programme (CAMP) Fuka-Matrouh – Egypt. UNEP/MAP/PAP, 1999.

17 OSPAR Commission, 2009. Assessment of the impact of coastal defence structures.

18 Arrow, K., B. Bolin, , R. Costanza, P. Dasgupta, C. Folke, C.S. Holling, B-O. Jansson, S. Levin, K-G. Maler, C. Perrings, C., and D. Pimentel, ,1995. Economic growth, carrying capacity, and the Environment. Science, 268: 520–521.

19 Wafar, M.V.M. 1997. Carrying capacity of coral reefs. Regional Workshop on the Conservation and Sustainable Management of Coral Reefs, C65-C70p. M.S. Swaminathan Res. Found., Chennai (India). http://drs.nio.org/drs/handle/2264/1995 29 Aug. 2012.

20 Kulkarni, V.A., V.S. Naidu and T.G. Jagtap. 2011. Marine Ecological Habitat. A case study on projected thermal power plant around Dharmantar creek, India. J. Environ. Biol. 32 : 213-219.

21 Vethamony, P. M.T. Babu, G.S. Reddy, K. Sudheesh, E. Desa, and M.D. Zingde, 2007. Estimation of carrying capacity of the Gulf of Kachchh, west coast of India in relation to petroleum hydrocarbon through oil spill modelling. Proceedings of the International Maritime-Port Technology and Development Conference. MTEC 2007, 505-511p. http://drs.nio.org/drs/handle/2264/785 Accessed 29 Aug. 12

22 Rajan, Brilliant, M.N. Muraleedharan Nair and G.K. Suchindan. Water Quality Study of Varkala Coast with Special Reference to Tourism Carrying Capacity. http://210.212.24.72/~kscsteuser/digital-library/digital/KSC/ksc19/08-Ecology%20&%20Environment/08-General/08-10.pdf accessed 29 Aug. 12.

2. Focus of the report

We are drowning in information, while starving for wisdom. The world henceforth will be run by synthesizers, people able to put together the right information at the right time, think critically about it, and make important choices wisely.

E.O.Wilson

2.1. The Convention on Biological Diversity

The loss of biodiversity at the global level has been of such concern that twenty years ago, in 1992, at the Earth Summit of the United Nations Conference on Environment and Development held at Rio de Janeiro, world leaders got together to agree to the Convention on Biodiversity. The convention recognized for the first time in international law that the conservation of biological diversity is “a common concern of humankind” and is an integral part of the development process. The convention has three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources (www.cbd.int). The convention entered into force on 29 December 1993. India ratified the CBD on 18.2.1994.

The Convention’s Governing Body is the Conference of Parties (COP), which advances implementation of the Convention through the decisions it takes at its periodic meetings. At the COP meeting in 1995 at Jakarta, the pressure on coastal and marine environments worldwide was highlighted and the statement of the Ministerial meeting held there referred to the new global consensus on marine and coastal biological diversity as the Jakarta Mandate on Marine and Coastal Biological Diversity. There is a programme of work with five key programme elements: Integrated Marine and Coastal Area Management, Marine and Coastal Living Resources, Marine and Coastal Protected Areas, Mariculture and Alien species and Genotypes. At COP 10 in Nagoya, it was decided ‘to align the targets of the programme of work on marine and coastal biodiversity with specific indicators and timelines included in the Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets (Decision X/29 Marine and Coastal Biodiversity)’. There are five strategic goals in the Aichi Targets and each has its own set of targets. Most relevant in the context of this study is Strategic Goal B: “Reduce the direct pressures on biodiversity and promote sustainable use”.

India hosted the 11th Conference of the Parties (COP) to the Convention in Hyderabad between 8th and 19th October 2012. One of the five issues communicated by the Indian Environment Minister as an agenda for the inter-ministerial meeting was coastal and marine biodiversity, especially the identification of ecologically and biologically significant marine and coastal areas (EBSA) as well as other issues.

2.2. INFC, NCPC and the CBD

Bombay Natural History Society (BNHS) is the nodal agency in India that facilitated the Global NGO Alliance on the CBD at COP 11. The forming of an Indian forum of NGOs and civil society representatives working on biodiversity issues and aspects was intended to take Indian conservation concerns and people's issues to the CBD COP 11 and MOP 6. The forum would be referred to as 'The Indian NGO Forum for CBD' (INFC) to both avoid confusion with the global CBD Alliance that also comprises NGOs (at global level) and to organize a build-up to the COP/MOP distinct from the official process by the Government of India (GoI).

A meeting was organized by the BNHS, Dakshin Foundation and the NFF (National Fishworkers Forum) on 'Coastal and Marine Biodiversity and livelihoods at the CBD COP11' on 18th February 2012 at Chennai. At the meeting, a number of action points were discussed including GIS mapping of ports and power plants and their impacts, with testimonies from affected parties. At the meeting of National Coastal Protection Campaign (NCPC) on 19th February 2012, NCPC member **PondyCAN** (Pondy Citizens' Action Network) along with **TISS** (Tata Institute of Social Sciences) **with funding support from BNHS** took up the responsibility of preparing the position paper for Coastal Area Management in India, with the aim of:

1. Assessing the existing and proposed development of the mainland coast of India
2. Presenting an overview of the challenges faced
3. Exploring integrated approaches.

It will involve building an interactive and working database through crowd sourcing (a process that involves distribution of tasks to a group of people) and will consist of geo-spatial mapping of all coastal developments (current and proposed) using open source platforms and tools with the long term goal of assessing the extent and implications of these developments on the coastal ecosystems and communities. This exercise will provide hard details at a national level to show that India's coastal areas have rich and diverse eco-systems, and are densely populated by settlements, commercial areas, structures and large developments like ports and power plants, which are having adverse impacts on biodiversity and livelihoods.

Such a national and holistic perspective will help government, planners and communities to make informed decisions.

2.3. Need for digitization and democratization of spatial information

India has had, since 1991, a legislation to protect the coast. This is the Coastal Regulation Zone Notification 1991 (under the EPA 1986), which was modified and notified afresh in 2011 as the CRZ 2011 Notification. In both cases, a 500 metre width of the coast from the high tide line (HTL) has been designated as the area where some activities are prohibited, some permitted, and others regulated. In 1991 Notification, the CRZ had four categories, with the fourth (CRZ IV) being 'islands'. In the 2011 Notification, category IV (CRZ-IV) has been defined as the water area up to 12 nautical miles from the low tide line.

The CRZ may be considered as a zoning law as it demarcates a specified width of the coast into various categories and sub-zones. It is a law based on geographic zonation which regulates permissible and non-permissible activities within each of the categories and sub-zones. In such laws, spatial information such as maps becomes the basis for implementation and monitoring, and such zoning laws are widely used for land use planning by local governments/local bodies. In the case of the CRZ, the map is called the Coastal Zone Management Plan (CZMP).

A major problem in the 1991 notification was the way in which the HTL was demarcated. Seven agencies/institutions were authorized to prepare the HTL maps but there was no consensus amongst them about the methodology, leading to differences in the way the HTL was demarcated. The demarcation of the HTL is crucial as it decides the 500 metre boundary of the CRZ. The Mundra case study elsewhere in this report shows how in government maps of 1996, the proposed Mundra SEZ fell within CRZ-I zone, but maps submitted by the proponent for clearance of the Water Front Development Project in 2008 marked the HTL 3 km south of what is shown in the state maps, and the maps submitted in 2009 for clearance of the SEZ further shifted the HTL again by 7 km[1].

1 Perspectives Group, 2012. "Swimming against the Tide Coastal Communities and Corporate Plunder in Kutch", Economic & Political Weekly, Vol - XLVII No. 29.

In the case of the CRZ, the availability of the CZMP enables implementation. When the original CRZ notification was issued on 19th February 1991, most states delayed or did not develop CZMPs. It was only after the Supreme Court of India's directive as a result of a public interest litigation[2] that the state governments began to prepare the CZMPs for their states, which are believed to have been submitted to the MoEF in 1996. Since the preparation of the CZMP, and 2011 when the new notification was issued, several amendments were made in the CRZ notification, but the CZMPs prepared based on the 1991 notification were not modified to incorporate these amendments[3].

A second problem is that in many states the scale of maps in the CZMPs makes it impossible to use it as the primary document for implementation. In some cases, the HTL, 200 m line and 500 m line were drawn on one map and the coastal regulation zones (I to III) on another. In other cases scales varied between these maps, making it impossible to overlay maps. The CZMPs should have also had plots identified with survey numbers on maps of cadastral scale (1:4000), in order to be used for CRZ implementation. Mapping also needs to be inclusive. For example, the feasibility report prepared by consultants[4] for an elevated highway in Chennai took into account and mapped only the formal residential boundaries of project-affected communities, and not two project-affected fishing hamlets[5]. Thirdly, there has been evidence to suggest that the zoning process itself has been faulty, which some experts believe was by design[6].

For obtaining CRZ clearance, hard-copy maps showing the project in the CRZ are of little relevance or use in decision making if they cannot be overlaid and compared with the government's CZMPs. From such hard-copy maps, even an expert would find it difficult to point out anomalies or make any sense of the map (even if the scale is the same). In this digital era, it is rather obvious that the way forward is to digitize and make maps available in the digital format. This concept is neither revolutionary nor new. There have been mapping exercises by the Ministry of Environment and Forests for the preparation of valuable atlases such as the National Mangrove Atlas, the National Coral Reef Atlas and the National Wetland Atlas. These digital databases have been made into books and hard copy atlases have been made available, but their greatest utility would have been if institutions had access to the data in digital form. The process of getting this (digital) information is yet to be understood by the project team, who were unsuccessful in getting the information in time for this report, despite the willingness of the people at the top to share it. A part of the problem is lack of procedural clarity on sharing of information.

Not just maps, but data sets need to be made available in the digital format as well. An example is the Marine Fisherfolk Census of 2010 carried out by the Central Marine Fisheries Research Institute, which has detailed information on fishing hamlets in terms of population, income, literacy, number of boats, nets. etc. While the census is not difficult to access, it is in hardcopy format which consists of thousands of pages of tables! Can one imagine the errors that can crop up if maps are to be generated or simple additions of sets of numbers are to be made, as the numbers have to be manually entered all over again? It is not surprising that organizations such as the South Indian Federation of Fishermen Societies (SIFFS) are creating spreadsheet databases[7] carrying out the data-entry of the tables from the publication themselves, as only then can they be effectively used to assess the status of the community and target areas for improvement. The project team has had to carry out this exercise to a limited extent to extract data relevant to this study.

The team has faced several problems while trying to collate data on a single platform. The MoEF could not provide a single Coastal Regulation Zone (CRZ) map for any state (all states have to submit coastal management zone maps to the MoEF for clearance) and it goes without saying that the MoEF should maintain a repository of such maps. Information on proposed power plants on the MoEF website is incomplete and in places inaccurate. The Department of Fisheries under the Ministry of Agriculture had data on fishing villages, but could not provide

2 Supreme Court Order dated 18th April 1996 in W.P.(C) No.664 of 1993 issued in the petition filed by the Indian Council for Enviro-Legal Action.

3 Coastal Zone Management Plan. http://crz.elaw.in/czmp.html accessed 19 September 2012.

4 Wilbur Smith Associates Pvt. Ltd 2009, Link Road from Light House on Kamarajar Salai to ECR Via Besant Nagar: Final Detailed Feasibility Report, Highways Department, Chennai.

5 Participatory mapping for the fishing community, http://www.transparentchennai.com/2011/02/09/participatory-mapping-for-the-fishing-community/

6 Menon, M. and A. Sridhar, 2007. An appraisal of coastal regulation law in tsunami-affected mainland India. In: Report on ecological and social impact assessments post-tsunami in mainland India; Submitted to UNDP. Post-Tsunami Environment Initiative. 105-149 p.

7 Pers. Comm. V. Vivekanandan, 11 September 2012.

their names or their locations and asked the team to contact individual states. Similarly, the website of the Ministry of Shipping does not list 'minor ports' no matter how big they are. This information is again said to be available only with the states. But not all the states can provide this. It was quite shocking to see that despite policies already put in place, the amount of information available in a consolidated and integrated manner is woefully inadequate. This just shows the lack of accountability and co-ordination, whether it is Centre-State or inter-State or inter-departmental. This is the specific reason for the exploratory study undertaken and presented in this report.

Early in February last year (2012), the government cleared the National Data Sharing and Accessibility Policy[8], which facilitates data sharing and enables access to government-owned data. The policy applies to all data and information created, generated and collected using public funds provided by the union government directly or through authorised agencies by various ministries, departments, organisations, agencies and autonomous bodies. The data and information has to be shared in both human-readable and machine-readable form. In the case of digital atlases, a sustainable mechanism can be created by which the atlas is maintained and updated, ensuring that it remains accurate and usable.

In the past five years spatial information, satellite imagery, maps, their digitization and map making itself has become simpler and cheaper, with the availability of free and open source software as well as the move towards creative commons attributes. Web-interactive activities are now the norm (web 2.0) where editing, sharing of information and data can be done by the viewer/user. The CAMP (Coastal Area Mapping Project) has demonstrated how digitized spatial information can be generated and shared cost-effectively using leading edge technology, making it simple and user-friendly in what can be called "sophisticated simplicity". Web GIS for CRZ that makes the CZMPs available is the way forward as the mechanism for smooth, effective, transparent and accountable implementation of the CRZ. It also creates space for informed participation by citizens, groups of citizens or Non-Governmental Organizations (NGOs) in the implementation of the law.

In the CRZ 2011, the specific methodology for the preparation of CZMP has been provided, and it is also understood that a common methodology would be developed for demarcating the HTL. The CRZ 2011 is also to be supported by the demarcation of the hazard line that has been assigned to the Survey of India (SoI) for mapping the entire coastline of the mainland of the country as part of the ICZMP project in India funded by the World Bank. The MoU between the SoI and MoEF was signed on 12th May 2010[9], and the SoI is carrying out flying operations along the coast to generate very high quality data that will enable the production of very detailed information about the coast, perhaps within the next year or two, at an enormous cost. Can we hope that this information will be made available to stakeholders in the digitized format? This is vital to empower all constituencies – communities, citizens, civil society, industry & business and the government – for their stewardship of the coast in an equitable manner in the spirit of the principles and values enshrined in the CRZ notification: sustainability, social and environmental justice.

2.4. Objective and methodology

The principal objective of this initiative and the related study is to make a preliminary assessment of the extent of coastal development activities that have taken place on the coast of India, as well as to gauge the overall impacts of these developments on coastal biodiversity and livelihoods. While the impacts of development and activities on coastal environments, biodiversity and livelihoods are many and varied, the most direct, visible and unquestionable impact is the direct loss of habitat that is caused by these. The mere physical occupation of the coastal environment by developments and their activities is of primary importance, as they reduce the space available for natural habitats as well as for the livelihood of those communities that directly depend on the renewable ecological resources, services and functions that are provided by these coastal habitats. Moreover, many of these developments and their related activities cause a direct loss of natural habitat in their vicinity, for instance when they trigger off severe, rapid and extensive erosion of the coast. The footprint of these developments on the physical coastal environment is therefore much larger than the physical space occupied by a given development. This study and the survey that was conducted for it therefore places greater emphasis on the direct loss of habitat that is caused by the mere physical occupation and physical destruction of the coastal environment by developments and their related activities.

8 National Data Sharing and Accessibility Policy (NDSAP) 2012. http://www.dst.gov.in/nsdi_gazette.pdf

9 National Project Management Unit of India. SICOM. http://www.sicommoef.in/about-us.aspx

The assessment of the extent of coastal development activities that have taken place on the coast of India is done with the use of a combination of geo-spatial and other data as well as literature. As this is a short-term, low budget project, the secondary objective is also to outline key areas for future research in order to get a clearer picture of the actions needed to protect biodiversity and livelihoods along the coast of India. While the study is a comprehensive one, it aims to maintain the highest standard possible with the available means and time, and also to create space for the data to be built upon, edited and reviewed through various sources and stakeholders. It must be kept in mind that the larger objective of the study is to advocate policy changes that will ensure the long-term sustainability of the coastline in India. The main activities of this study are to:

- use geo-spatial data to identify, enumerate and map coastal structures like seawalls, groynes and jetties to view the physical impact of these structures on the coast;
- identify, enumerate and map current and proposed ports, power-plants and commercial activities and developments such as special economic zones along the coast;
- identify, enumerate and map coastal settlements and human habitats along the coast;
- enumerate and map water bodies situated along the coast;
- assess the likely impacts of infrastructure projects on biodiversity along the coast;
- assess the likely possible impacts of infrastructure projects on livelihoods of communities dependent on coastal and maritime ecosystems;
- outline a framework that can ensure the minimization of biodiversity and livelihood losses along the coast of India;
- implement methodologies that can be replicated with low budgets and minimal skills so that the maximum number of people can adopt them;
- involve all the stakeholders, particularly from the coastal communities, and engage with them to make them part of this initiative. The coastal communities can contribute in many of the activities listed above, as they possess first-hand knowledge of the issues that they are facing and observing. This was done informally during this introductory phase of the study, but it is hoped that it will play a larger part in subsequent phases.

The assessment of the extent of coastal development activities that have taken place on the coast of India was conducted by collecting geo-spatial information from a “virtual” survey of the entire coastline of mainland India with the use of “Google Earth” maps and other geo-spatial navigation tools, as well as through the review of literature.

Data pertaining to the position, enumeration and extent of the following coastal developments was collected from “Google Earth” satellite imagery. The majority of the information collected from the satellite imagery is from the years 2009 to 2011. However, in some rare instances the information is as old as 2003, and even as recent as 2012. The exact date of the imagery for all information collected can be found in Annexure I.

The survey of the coast through “Google Earth” has covered the following coastal developments and activities which were visible and which could be clearly identified on the satellite available imagery:

A) Coastal structures: i) seawalls (& revetments), ii) groynes, iii) piers (& trestles), iv) jetties, v) breakwaters, vi) docks, vii) detached breakwaters, viii) bridges, ix) elevated roads, x) marine outfalls, xi) pipelines.

B) Ports & harbours: i) major and minor ports, ii) commercial harbours, iii) fishing harbours.

C) Power plants: i) thermal, ii) nuclear.

D) Human settlements: i) fishing villages and hamlets, ii) towns, iii) cities

E) Commercial activities (except agriculture): i) salt extraction, ii) aquaculture, iii) tourism activities like resorts, hotels, iv) sand mining, v) institutional, vi) industrial.

F) Water bodies: i) estuaries, ii) rivers, iii) irrigation/storage tanks.

G) Notified Marine Protected Areas.

For this study, only those developments and activities listed above that were located in the littoral zone (defined further below) and within the 500 metre zone of the landward side of the shoreline were taken into account. In the exceptional case of power plants, the coastal area up to a landward distance of 10 km was surveyed, as coastal power plants are often located well beyond the 500 metre line of the landward side of the shoreline.

The rationale for restricting the area surveyed to the littoral zone and the 500 metre zone of the landward side of the shoreline is the following.

Littoral zone:

Definition of littoral zone: In marine ecosystems the shore area or intertidal zone, where periodic exposure and submersion by tides is normal[10].

The littoral zone is that part of the coastal environment along the shore that is in direct contact with the marine environment and is closely connected to and dependent on the coastal processes that occur along the coast. It is also a highly dynamic environment which undergoes continuous change on an hour to hour, day to day basis, and is sustained by a complex chain of inter-related processes.

Human developments and activities in the littoral zone have a rapid as well as long-lasting effect and impact on the processes and systems that occur in that zone. Changes that take place in the littoral zone therefore have a direct impact on the biodiversity and livelihoods of all those who are closely connected to or dependent on the processes that occur in that zone. The developments and activities that take place in the littoral zone are therefore of great significance and interest for this study of the coastal environment.

In this study, the landward boundary of the littoral zone is assumed to coincide with the high tide line (HTL). The landward extension and areas of the littoral zone, such as those zones which fall within estuaries, creeks, rivers, etc., that are located further inland, away from the marine environment, are not included in the survey. Only the seaward side of the littoral zone (as illustrated in the figures below) was surveyed.

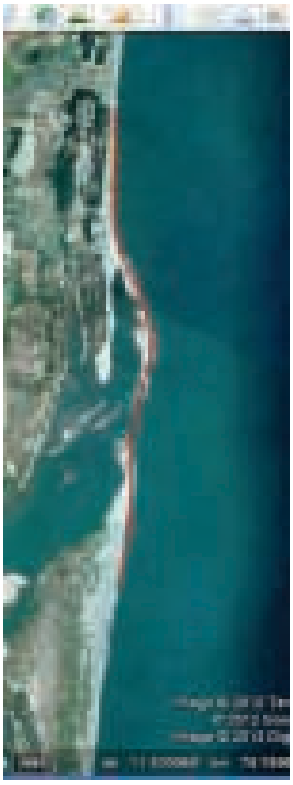
Examples of the landward boundary (red line) of the marine littoral zone surveyed at the following locations		
River mouth	**Sandy beach**	**Mouth of estuary**
		

Figure 2.1: Landward boundary (red line) of the marine littoral zone surveyed at river mouth, sandy beach, mouth of estuary

10 Allaby M. (1998). *Oxford Dictionary of Ecology* (2nd Ed). Oxford University Press: Oxford, (UK). 440pp.

The landward extension and areas of the littoral zone were excluded from this survey because the boundaries and extent of the littoral zone between the marine and other connected landward aquatic environments is difficult to determine.

500 metre zone from shoreline:

The 500 meter zone that is located landward from the high tide line (HTL) falls under the Coastal Regulation Zone (CRZ) Notification (2011). The CRZ 1991 and later 2011 was formulated "with a view to ensure livelihood security to the fisher communities and other local communities living in the coastal areas, to conserve and protect coastal stretches, its unique environment and its marine area, and to promote development through sustainable manner based on scientific principles taking into account the dangers of natural hazards in the coastal areas, sea level rise due to global warming." (CRZ Notification 2011).

This area, defined by the 500 metre zone along the shoreline, is therefore of significant interest with regards to developments and activities along the coast, as these are regulated by the Government. One may therefore also consider that legally speaking, according to the CRZ 2011, all zones that are within the 500 metre zone from the HTL are therefore the only parts of the coastal environment that enjoy special protection and regulation of development. The coastal environment, its biodiversity and ecology and the livelihoods of the people that are dependent on it is therefore protected and regulated only within the 500 metre zone from the HTL. The developments and activities within this 500 metre zone are therefore of great significance to the biodiversity and livelihoods in this area and have thus been included in this survey.

As maps for the CRZ of the entire nation are not available yet, the 500 metre zone that has been surveyed has been determined in an approximate manner with the use of measuring tools available in "Google Earth."

The detailed methodology of the survey of the coast through "Google Earth" is provided in Annexure II.

Secondary information collected from various sources has been used to validate as well as derive an understanding of both the physical and ecological impacts of these structures. These sources mainly include published reports as well as articles from journals and seminar/workshop/conference proceedings apart from media reports. A number of technical papers are easily accessible on the internet thanks to the digital repositories at the National Institute of Oceanography, Central Marine Fisheries Research Institute, and the Ministry of Earth Sciences. While some websites are well maintained and up to date, others are not, and some even give different information on different subpages. This has been a problem as it is difficult to find out which is the most recent version of the information.

2.5. Disclaimer

This is a challenging work which has been started but which is in progress, and hence, at this moment, information is likely to be incomplete in certain areas. There have been challenges in terms of time as well as in access to information. Since this is a first attempt at consolidation of information to present a national overview, there are bound to be discrepancies and deficiencies. For instance, the data collected from the "Google Earth" satellite imagery was not ground-truthed and there are likely to be some differences between it and ground reality. However, these differences are expected to be minimal, as the elements that were surveyed – like seawalls, groynes, ports, harbours, power plants, settlements, etc. – can be clearly distinguished in the available satellite imagery. Moreover, if at all there are discrepancies, these are likely to be in the nature of erroneous exclusion of data that should have been collected but which got missed out. Therefore, in terms of errors in assessments, these are likely to give more conservative estimates than real.

The non-availability of information on the official position of the high tide line (HTL) as well as the Coastal Regulation Zones (CRZ) also means that survey of the littoral zone and the 500 metre zone is approximate. Moreover, as the survey was conducted using satellite imagery, tidal variations used to determine the HTL were also ignored, which have resulted in approximations. Also, the difficulty in defining and identifying the boundaries of the littoral zone, particularly the landward extension and areas of the littoral zone into estuaries, rivers, creeks, etc, has meant that some of the boundaries of the littoral zone were arbitrarily defined. However, such instances are only a small minority.

Lastly, even though the authors of this report are certain that the information presented here represents quite accurately the developments and the activities that are taking place along the coast, as a next phase of this study

it is proposed to undertake validation of the data that has been collected as well as the methodologies adopted for the surveys. The authors also welcome those who wish to contribute to this exercise.

All attempts have been made to use information from authentic sources, for which citations are provided. The authors welcome any information that would improve the quality and content of the report to make it more complete in a future edition.

2.6. Beyond the horizon: post CBD COP 11, 2012

Creating a web 2.0 GIS database like wiki (where the web is a platform for information sharing, interoperability, user-centred design, and collaboration) that can be constantly updated has been an area of interest and thrust for members of both PondyCAN and TISS. Thanks to the initial funding support from BNHS in kick-starting this report, the database is on a web GIS platform and open initially to users from the NCPC and ultimately to everyone. This is the first step of this open-ended and evolving project.

Subsequent steps will include ground-truthing of information already collected, surveyed and mapped; collection of additional data; procurement of time-line series maps over specific periods to see the changes; additional studies along the lines of the ones in this report; and setting up of a dedicated group who will continue this work and manage the database and periodically update it. This would have to be a collaborative effort hopefully involving many of the stakeholders.

NCPC will take the initiative to build collaboration between its members, the GOI, all the State governments, institutions, industries and businesses – in effect all the stakeholders – for the conservation, protection and restoration of India's coastline despite the numerous demands on it.

3. Coastal ecosystems and processes

No phenomenon can be isolated, but has repercussions through every aspect of our lives.
We are learning that we are a fundamental part of nature's ecosystems.

- Arthur Erickson

3.1. The littoral zone

The littoral zone is defined as the shore area or intertidal zone, where periodic exposure and submersion by tides is normal[1]. This is where the lithosphere, hydrosphere and atmosphere meet; also the region where physical, biological and biogeochemical processes are directly affected by land. The coastal zone usually includes the coastal ocean as well as the land adjacent to the coast that influences coastal waters. There is no clear operational definition of the coastal zone. In oceanography and marine biology, the idea of the littoral zone is extended roughly to the edge of the continental shelf. Starting from the shoreline, the littoral zone begins at the spray region just above the high tide mark. From there, it moves to the intertidal region between the high and low water marks, and then out as far as the edge of the continental shelf[2]. Within its extent, the coastal ocean and the immediately landward region of the coastal zone displays a wide diversity of geomorphological types and ecosystems, ranging from sandy beaches to mangroves, coral reefs and seagrass beds.

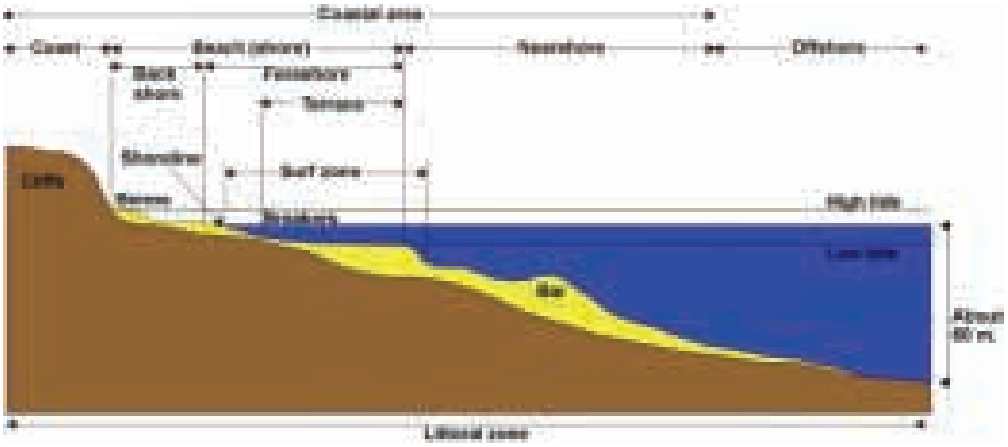


Figure 3.1: Littoral zone[3]

The coastal ocean constitutes one of the most geochemically and biologically active areas of the biosphere.

1 Allaby M. (1998). *Oxford Dictionary of Ecology* (2nd Ed). Oxford University Press: Oxford, (UK). 440pp.
2 "Littoral Zone" http://en.wikipedia.org/wiki/Littoral_zone Accessed 23 July 2012.
3 Marine Habitats. http://www.dcbiodata.net/explorer/res/Coast%20general_med.jpg Accessed 4 August 2012

For example, it accounts for at least 15% of oceanic primary production, 80% of organic matter burial, 90% of sedimentary mineralization, 75-90% of the oceanic sink of suspended river load, and about 50% of the deposition of calcium carbonate. Additionally, it represents 90% of the world fish catch, and its overall economic value has been recently estimated as at least 40% of the value of the world's ecosystem services and natural capital[4].

The ocean surface is in constant motion, creating waves and swells mainly because of wind. The dominating current in the near-shore zone, running parallel to the coastline, is the longshore current that generates oblique breaking waves which result in the transport of sediment along a coast, at an angle to the shoreline. The long-shore transport of sediment, also known as the littoral drift, typically takes place within a sediment cell – a section of the littoral zone where sediment inputs, throughput and outputs may be considered to be part of a closed system[5], which can be a few kilometres to hundreds of kilometres in length. Longshore drift (or littoral drift) therefore plays an important role in the evolution of a shoreline.

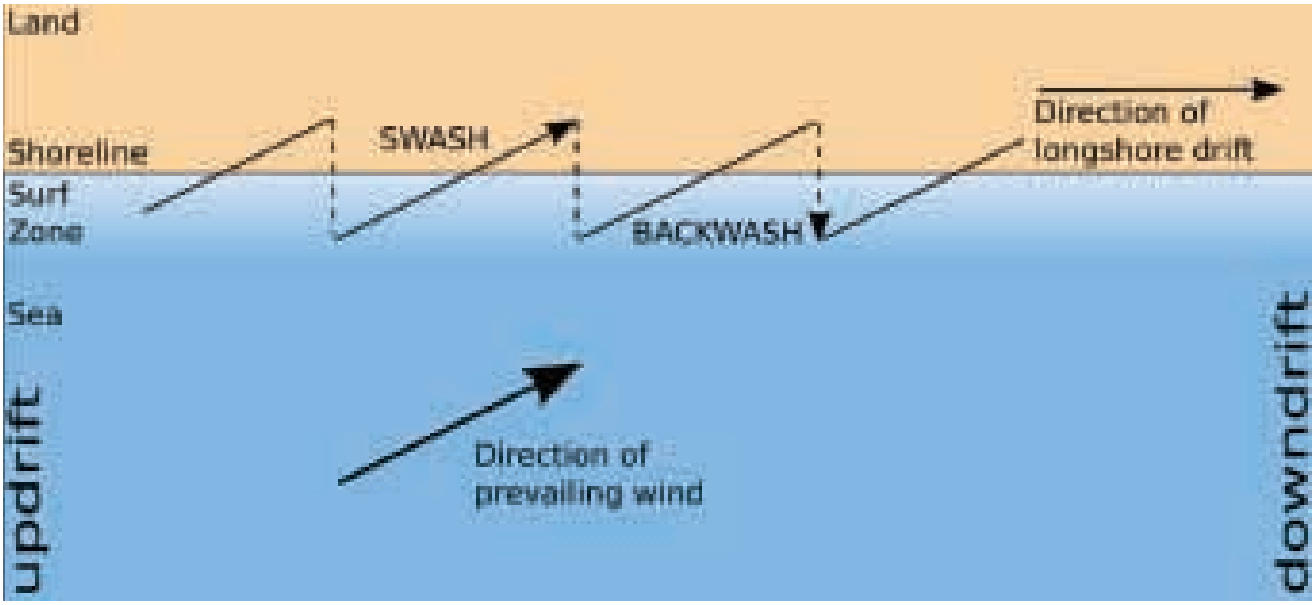


Figure 3.2: Longshore drift[6]

The littoral zone is typically in a constant state of flux, with constant movement and exchanges of sediment both along and across the shore. Table 3.1 indicates that the entire coast of India, both the Western Malabar coast as well as the Eastern Coromandel coast, are characterized by natural movement of sand, the littoral drift. More significantly, most parts of the coast have a net transportation of sediment along the shore, which means that sand is predominantly moving in one direction. The implications of a net long-shore transport of sediment is that any disturbance to the flow of sediment, for example caused by a manmade structure like a breakwater, is likely to upset sediment balances within the given sediment cell. Sediment cells, particularly along the east coast of India, are considerably large, extending for over hundreds of kilometres, therefore any obstruction of flow of sediments along the path of the littoral drift within a cell can significantly affect large parts of the coastline.

4 Gattuso, Jean-Pierre, Stephen V. Smith (Lead Author);C Michael Hogan (Contributing Author);J. Emmett Duffy (Topic Editor) "Coastal zone". In: Encyclopedia of Earth. Eds. Cutler J. Cleveland (Washington, D.C.: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth April 15, 2010; Last revised date 8 April 2011; Retrieved 13 August 2012. <http://www.eoearth.org/article/Coastal_zone?topic=58074>

5 Goudie, A.S. (Editor). 2004. Encyclopedia of Geomorphology, Pg. 931. New York.

6 Longshore drift http://en.wikipedia.org/wiki/File:Longshore_drift.svg accessed 1 August 2012.

Table 3.1: Estimated sediment transport rates at various locations in India[7]

Location	Net transport (m^3/yr)		Gross transport (m^3/yr)
West coast of India			
Kalbadevi	118,580	South	147,621
Ambolgarh	189,594	South	299,997
Vengurla	53,040	South	120,141
Calangute	90,000	South	120,000
Colva	160,000	North	160,000
Arge	69,350	North	200,773
Gangavali	142,018	South	177,239
Kasarkod	40,186	North	77,502
Maravanthe	25,372	North	29,836
Malpe	14,169	South	106,641
Padubidri	89,358	South	385,469
Ullal	36,165	South	38,273
Kasargod	736,772	South	958,478
Kannur	19,434	South	561,576
Kozhikode	114,665	South	256,697
Nattika	192,818	North	660,276
Andhakaranazhi	202,096	South	599,484
Alleppey	16,929	North	62,519
Kollam	383,784	South	805,296
Thiruvananthapuram	99,159	North	1231,153
Kolachel	302,400	West	946,500
East coast of India			
Ovari	1,500	South	251,300
Tiruchendur	64,100	North	87,500
Kannirajapuram	117,447	North	145,979
Naripayur	36,600	South	122,500
Muthupettai	5,200	South	8,900
Pudhuvalasai	5,300	South	42,900
Vedaranivam	51,100	North	94,100
Nagore	96,000	South	433,000
Tarangampadi	200,600	North	369,400
Poompuhar	146,000	North	478,800
Pondicherry	134,400	North	237,000
Periyakalapet	486,900	North	657,600
Tikkavanipalem	177,000	North	405,000
Gopalpur	830,046	North	949,520
Prayagi	887,528	North	997,594
Puri	735,436	North	926,637

7 Sanil Kumar, V., K.C. Pathak, P. Pednekar, N.S.N. Raju & R. Gowthaman. 2006. Coastal Processes along the Indian coastline. Current Science, Vol. 91, No. 4, pp. 530-536.

As shown in table 3.1, along the west coast the net transport of sediment is towards the south. On the Malabar coast the largest amount of sediment transport is found on the southern part of the coast, in the state of Kerala. Along the east coast of India, the net transport of sediment is towards the north. On the Coromandel coast the largest amount of sediment transport is found on the northern part of the coast, in the state of Orissa. Littoral drift is greater and plays a more significant role along the eastern coast of India.

A number of human actions/interventions can change the structure of the intertidal zone by causing an alteration in the sedimentary and hydrodynamic regimes. Such changes can result in modification of the existing intertidal zone over a variety of temporal and spatial scales.

3.2. Ecosystems of the littoral zone

The world's coastal regions are subdivided by physical rather than biological characteristics and include an array of near-shore terrestrial, intertidal, benthic and pelagic marine environments (table 3.2).

Table 3.2: Coastal ecosystems[8]

	LOCATION	EXAMPLES
1.	Near-shore terrestrial	Dunes, cliffs, rocky and sandy shores, coastal xeromorphic habitats, urban, industrial and agricultural landscapes
2.	Inter-tidal	Estuaries, mangrove forests, mudflats, salt marshes, salt pans, sea grass, lagoons, corals, rocky and sandy shores other coastal wetlands, ports and marinas
3.	Benthic	Seagrass meadows, sea weed ecosystems, coral reefs, and soft bottom environments above the continental shelf, artificial reefs and structures
4.	Pelagic	Open waters above the continental shelf (inclusive of neritic and oceanic)

In this study, the focus is mainly on the near-shore terrestrial habitat – sandy and rocky shores, and the inter-tidal wetlands – especially estuaries, mangroves, mudflats and coastal lagoons. The different types of natural coastlines in India have been classified and their extents have been assessed (Table 3.3)[9]. About 90% of India's natural coastal environment is "soft" i.e. sandy, muddy or marshy, the rest being rocky. Sandy beaches are the most widespread, covering about 43% of the coastline.

The "soft" composition of India's coastline indicates that most parts of India's shoreline are vulnerable to change. Understanding the complex dynamics and processes that occur along the soft shorelines is absolutely necessary before subjecting them to anthropogenic changes. The poor understanding of these factors and processes is the main cause of the man-made destruction and loss of coastal habitat along these soft coastlines in India.

Table 3.3: Types of coastlines in different States

State	Sandy beach (%)	Rocky coast (%)	Muddy flats (%)	Marshy coast (%)	Total length* (km)
Gujarat	28	21	29	22	1214.7
Maharashtra	17	37	46	-	652.6
Goa	44	21	35	-	151.0
Karnataka	75	11	14	-	280.0
Kerala	80	5	15	-	569.7
Tamil Nadu	57	5	38	-	906.9
Andina Pradesh	38	3	52	7	973.7
Orissa	57	-	33	10	476.4
West Bengal	-	-	51	49	157.5
Daman and Diu					9.5
Pondicherry					30.6
Total mainland	43	11	36	10	5422.6
Lakshadweep					132.0
Andaman and Nicobar					1962.0
Total					7516.6

*According to the Naval Hydrographic Office.

8 Adapted from Burke, Lauretta, Yumiko Kura, Ken Kassem, Carmen Revenga, Mark Spalding, and Don McAllister, Pilot Analysis of Global Ecosystems: Coastal Ecosystems, World Resources Institute, Washington D.C. April 2001.

9 Sanil Kumar, V., K.C. Pathak, P. Pednekar, N.S.N. Raju & R. Gowthaman. 2006. Coastal Processes along the Indian coastline. Current Science, Vol. 91, No. 4, pp. 530-536.

Sandy beaches: Of greatest general interest to humans are the sandy shores – the wide beaches with dunes. Longshore drift, as well as other actions such as windblown sand, build up beaches. A beach is defined as 'the zone of unconsolidated material that extends from the mean low water line (low tide region) to the place where there is a marked change in material or physiographic form, or to the line of permanent vegetation (the effective limit of storm waves and storm surge), i.e. to the coastline[10]. The beach or shore can be divided into the foreshore and the backshore.

PHOTO: SATISH BABU

Figure 3.3: A beach on the Malabar Coast, India

The major source of sediments transported by longshore drift is rivers. Humans have simultaneously increased the sediment transport by global rivers through soil erosion (by 2.3 ± 0.6 billion metric tonnes per year), and reduced the flux of sediment reaching the world's coasts (by 1.4 ± 0.3 billion metric tonnes per year) because of retention within reservoirs[11]. It is estimated that about 70 per cent of the world's sandy shorelines are eroding (Bird, 1985, quoted in Leatherman et. al., 1994[12]) and most of today's coastal erosion is likely to be driven by anthropogenic factors. Unfortunately, sandy beaches and dunes are easy to level and build upon, whereas the importance of conserving sandy beaches and sand dune ecosystems is not fully understood. This is of great concern because sandy beaches and sand dunes are important on many counts. They:

- form an effective barrier between hazards that originate from the ocean,
- form a barrier between the seawater and fresh water which may occur in lenses/aquifers along the coast, thus preventing seawater intrusion,
- are used as spaces for recreation for millions,
- are spaces occupied by the fishing community, especially the small scale communities that use them in the pursuit of their livelihood, for landing, sorting, drying and selling fish, mending and drying nets, storing engines, beaching craft, even building homes,
- are used by nesting sea turtles,
- are an important link between terrestrial and marine habitats, and as such a habitat for certain specialized fauna and flora.

Sand dunes are mostly small hills formed by accumulation of sand due to action of tides, waves and wind. The process is known as the **Aeolian process**.

Types of sand dunes:

1. Foredunes: Foredunes may consist of hummocks or ridges in one or more lines parallel to the shore.
2. Parabolic dunes: Parabolic dunes and blowouts occur where strong winds blow sand inland and trailing ridges are held by vegetation.
3. Transgressive dunefields: Transgressive dunefields develop where strong winds blow large amounts of sand inland from exposed, usually dissipative, beaches.

Though it may be difficult to imagine, the sandy shore is also a rich ecosystem with high biodiversity, even in a harsh terrain. Sand dune flora consists of approximately 338 floral species of which 92 species are common to both the east and west coasts of India.

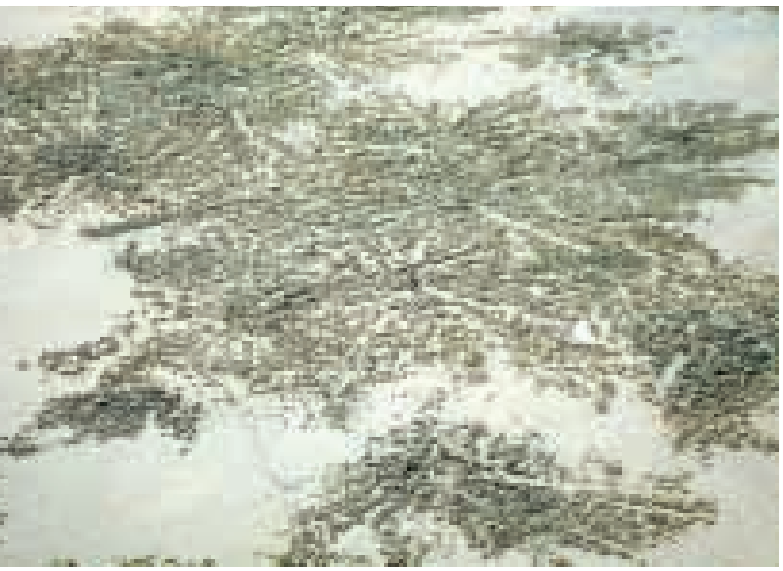
Some of the more obvious flora on a sandy beach are the *Spinifex* grasses that bind sand, and *Ipomea* creepers, while fauna include varieties of crabs and molluscs, most of which are the burrowing kind, and larger

10 Mangor, Karsten. 2004. "Shoreline Management Guidelines". DHI Water and Environment, 294pp. From: http://www.coastalwiki.org/coastalwiki/Beach accessed 9 August 2012.

11 Syvitski, J., C. J. Vorosmarty, A.J. Kettner and P. Green. 2005. Impact of humans on the flux of terrestrial sediment to the global coastal ocean. Science. 308: 376-380.

12 *Leatherman, Stephen P., A. Todd Davison and Robert J. Nicholls. "Coastal Geomorphology", in National Research Council. Environmental Science in the Coastal Zone: Issues for Further Research. Washington, DC: The National Academies Press, 1994.* http://www.nap.edu/openbook.php?record_id=2249&page=44

animals like sea turtles that visit the beaches for nesting. Most of the species that inhabit sandy beaches are small-size scavengers that make burrows or occupy interstitial spaces between sand grains. These sandy beach dwellers exhibit remarkable physiological and behavioural adaptation to changing environmental conditions. The contribution of living communities of sandy sediment to nutrient cycling and other ecological processes is probably substantial, but the details of such interactions are still poorly understood[13].



PHOTOS: SATISH BABU

Figure 3.4: Crab tracks on sand

Figure 3.5: Ipomea creeper on the backshore

Mangroves: Mangroves are largely restricted to tropical coastlines between 30^{O}N and 30^{O}S latitudes of the deltaic regions. They are salt-tolerant trees that grow in saline coastal sediment habitats, mostly in depositional coastal environments, where fine sediments (often with high organic content) collect in areas protected from high-energy wave action. They have adapted to live in hostile environmental conditions – water-logging, tidal

PHOTO: DEBI GOENKA

Figure 3.6: Mangroves, Bhitarkanika, Odisha

13 Sandy beaches as Biocatalytical Filters. http://www.marbef.org/wiki/Sandy_beaches_as_Biocatalytical_Filters Accessed 15 August 12.

variation and strong winds. They have morphological and physiological adaptations to these extreme conditions, such as stilt/prop/buttress breathing roots, salt extrusion and salt exclusion capability, and show vivipary. Growing in the intertidal areas and estuary mouths, they provide a critical habitat for a variety of marine and terrestrial flora and fauna. They provide nursery habitat for many species, including commercial fish and crustaceans, and thus contribute to sustaining the local abundance of fish and shellfish populations. Mangroves are also known to be major spawning and nursery grounds for shrimps. Their complex root systems enable trapping of sediments while slowing down water flow. Mangroves supply nutrients to adjacent coastal water, coral reef and seagrass communities, sustaining these habitats' primary production and general health. Mangroves serve as a source of firewood and green fodder. It is not known what percent of the world's coastlines were covered by mangroves before humans began to alter coastlines, but it is believed that the area has declined considerably, particularly in the last five decades[14]. In Sunderbans they provide a living for people to collect honey and other non-timber forest produce and are the home of tigers seen nowhere else in mangroves.

Estuaries: Forming a transition zone between freshwater and marine environments with the inflow of both seawater and freshwater providing high levels of nutrients in both the water column and sediment, estuaries are among the most productive of ecosystems. They are typically classified by their geomorphological features or by water circulation patterns and can be referred to by many different names, such as bays, harbours, lagoons, inlets, or sounds, although sometimes these water bodies do not necessarily meet the above criteria of an estuary and may be fully saline. Estuaries are amongst the most heavily populated areas throughout the world, with about 60% of the world's population living along estuaries and the coast. As a result, estuaries are suffering degradation by many factors, ranging from sedimentation to pollution to reclamation[15]. They have little wave action and hence provide a calm habitat from the open sea. They also provide rich feeding grounds for coastal fish and migratory birds, and spawning areas for fish and shellfish.

PHOTO: COPYRIGHT NICOLAS CHORIER

Figure 3.7: The Chunnambar estuary, Pondicherry

Mudflats: Also known as tidal-flats, are coastal wetlands that form when mud is deposited by tides or rivers. They are found in sheltered areas such as bays, bayous, lagoons and estuaries. Mudflats may be viewed geologically as exposed layers of bay mud, resulting from deposition of estuarine silts, clays and marine animal

14 Burke, Lauretta, Yumiko Kura, Ken Kassem, Carmen Revenga, Mark Spalding, and Don McAllister, Pilot Analysis of Global Ecosystems: Coastal Ecosystems, World Resources Institute, Washington D.C. April 2001.

15 Estuary. http://en.wikipedia.org/wiki/Estuary Accessed 15 August 2012.

detritus. Most of the sediment within a mudflat is within the intertidal zone, and thus the flat is submerged and exposed approximately twice daily. These support a large population of wildlife, especially migratory birds which come for the rich marine fauna – like algae, polychaetes, molluscs, and crustaceans such as crabs and prawns and fish such as mudskippers that are often seen here. Mudflats are present in almost all coastal states in India, but are often listed as wastelands in revenue records. Destruction of mudflats due to construction of ports, fishing harbours, industries, oil exploration and plantations can result in disruption of foraging and migration of birds[16].

PHOTO: DEBI GOENKA

Figure 3.8: Mud-flats at Nhava, Maharashtra

Seagrass beds: Seagrasses are submerged aquatic vegetation (SAV) that have evolved from terrestrial plants to live in the marine environment. Seagrasses grow from the regularly inundated intertidal zone to nearly 15 m depth in sandy subtidal zones. Like terrestrial plants, seagrasses have leaves, roots, conducting tissues, flowers and seeds, and manufacture their own food via photosynthesis. However, they have weak stems and their blades are supported by the natural buoyancy of water, remaining flexible when exposed to waves and currents. They are the main diet of Dugongs and Green Turtles and provide a habitat for many smaller marine animals, like shrimps and fish of commercial importance. They also absorb nutrients from coastal run-off and stabilise sediment, helping to keep the water clear. Because they support high biodiversity, and because of their sensitivity to changes in water quality, they have become recognized as important indicators that reflects the overall health of coastal ecosystems. The major seagrass meadows in India exist along the southeast coast (Gulf of Mannar and Palk Bay) and in the lagoons of islands of Lakshadweep in the Arabian Sea and in the Andaman and Nicobar Islands in the Bay of Bengal. The natural threats to seagrass in India are cyclones, waves, intensive grazing and infestation of fungi and epiphytes, as well as “die-back” disease. Seagrass beds are under extensive threat from anthropogenic activities such as deforestation in the hinterland, construction of harbours or jetties, and loading and unloading of construction material, as well as anchoring and moving of vessels, dredging and discharge of sediments, land filling and untreated sewage disposal. Increased sediment load (another result of the above natural and anthropogenic activities) in the overlying waters of seagrass meadows reduces the amount of ambient light, thus resulting in lower productivity due to the decline in photosynthetic processes and increased respiration[17].

16 Rahmani, A.R. Mudflats: The Cradle of Life. BNHS. www.bnhs.org

17 Seagrass-watch. http://www.seagrasswatch.org/India.html

PHOTO: C JOHN DEGLER

Figure 3.9: Trigger and surgeon fish schooling above a 32 metre deep reef 15 km off the coast of Pondicherry

Coral reefs: Often called rainforests of the sea, coral reefs form extremely diverse ecosystems because of the niches that they can provide. They are also physical ecosystem engineers, stabilizing shoreline change by breaking the force of waves as they reach the shore. They consist of colonies of tiny living animals called polyps thatcluster in groups and build a hard exoskeleton. Reefs grow best in warm, shallow, clear, sunny and agitated waters. Coral reefs are fragile ecosystems, partly because they are very sensitive to water temperature. Their symbiotic association with algae called zooxanthellae provides them with products from photosynthetic activity, and in turn the corals provide them with carbon dioxide. When temperatures go up, as due to warming of surface water (climate change impact), zooxanthellae get expelled, giving rise to coral bleaching phenomena. Corals are also under threat from ocean acidification, extraction for construction (including production of lime), blast fishing, cyanide fishing for aquarium fish, overuse of reef resources, and harmful land-use practices, including urban and agricultural runoff and water pollution, which can harm reefs by encouraging excess algal growth due to the supply of nutrients. Smothering of corals due to deposition of silt is also a major problem. All three types of reefs – atoll, fringing and barrier – occur in India.

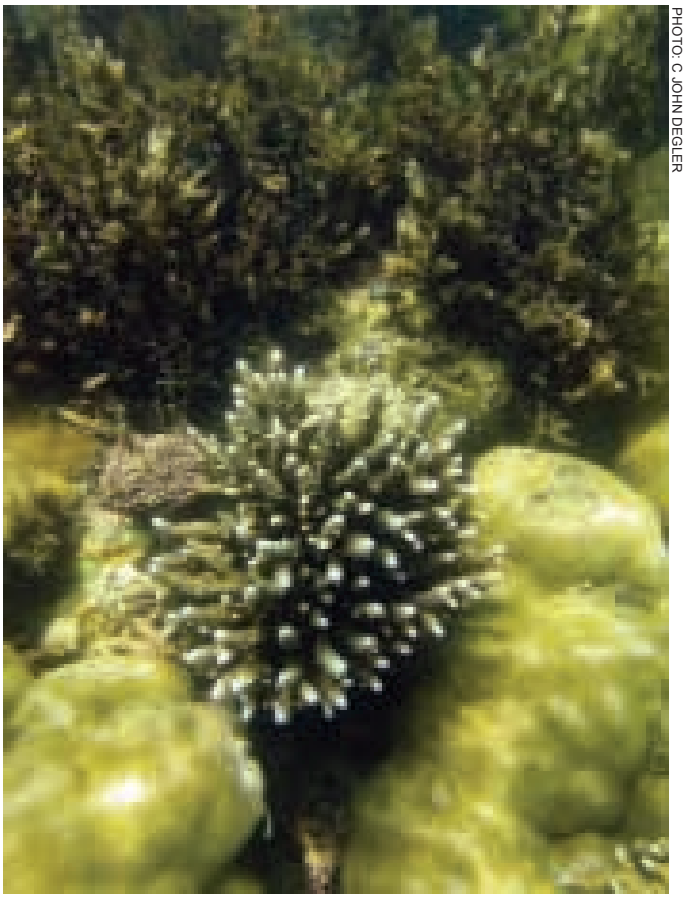


PHOTO: C JOHN DEGLER

Figure 3:10 Coral, Rameswaram

3.3. Physical ecosystem engineers

In addition to playing the role of major ecosystems in food production and the extensive biodiversity they contain, in the context of the current study it is pertinent to briefly describe the role and importance of physical ecosystem engineers. These include both plants and animals, microscopic and macroscopic. These organisms have been found to physically engineer estuarine and coastal ecosystems, affecting benthic and pelagic, nearshore (terrestrial) and interfacial (inter-tidal) environments composed of sediments, soils and rocks[18]. Among the many examples, one structural change that can be easily identified and understood is the extensive creation and maintenance of emergent physical structures by dune accreting and dune stabilizing grasses, mangroves, coral reefs, salt marshes and seagrasses. The

18 Gutiérrez, J.L., Clive G. Jones, James E. Byers , Katie K. Arkema, Katrin Berkenbusch , John A. Commito, Carlos M. Duarte, Sally D. Hacker, Iris E. Hendriks, Peter J. Hogarth, John G. Lambrinos, M. Gabriela Palomo and Christian Wild. (2012) Physical ecosystem engineers and the functioning of estuaries and coasts. Chapter 5, in Volume 7: Functioning of Estuaries and Coastal Ecosystems, (eds., C. H. R. Heip, C. J. M., Philippart, and J. J. Middelburg) in the Treatise on Estuarine and Coastal Science Series eds., E. Wolanski, and D. McLusky), Elsevier.

abiotic changes they bring include attenuation of storm surges and wind impacts, decreased shoreline erosion and protection of inland systems. Dune plants use two major techniques to dramatically modify the physical environment by capturing blowing sand to stabilize and shape what would have been a highly unstable shifting sand environment: dissipation of wind energy by forming a boundary layer around the vegetation and by sand actually hitting the surface of the plant. The latter is made use of by many coastal communities who have traditionally valued the protective ability of sand dunes. They plant leaf fronds of the Palmyra palm which trap the sand particles and allow the building up of a dune and the growth of *Spinifex* (locally known as Ravana's moustache).

PHOTOS: PRASHANT HEDAO

Fig 3.11a - Building and stabilising sand dunes

Fig 3.11b - Building and stabilising sand dunes

Similarly, a number of animals, especially burrowing organisms, create spaces between sand grains and allow gaseous interchange, apart from changing the texture of the soil. Others such as detritus feeders enable the clean-up of beaches, allow the breakdown of complex organic molecules into simpler constituents, and help in the cycling of nutrients and other minerals. Unfortunately, the destruction of coastal habitats also results in the breakdown of ecosystem services provided by organisms that are involved in physical engineering activities. Guiterrez et al. list some of the pathways of human impacts on physical engineers:

- direct exploitation at unsustainable levels (e.g. oysters, mussels, crabs, corals)
- destruction of naturally engineered structures due to fishing activities (bottom trawling)
- waste production (pollution)
- habitat transformation for urbanization and other human uses (dune flattening, mangroves into shrimp farms, blocking/diversion of estuaries, creeks)
- current and future impacts related to global climate change (e.g. storm force amplification, SLR which would result in submergence of salt marshes, etc.)
- building canals / channels for navigation (increases spread of propagules of invasive species).

Thus, loss of habitat and associated biodiversity can be a lot more serious as restoration is not an easy task, nor as simple as planting more trees or dumping sediment in eroding areas of the coast.

4. Coastal Communities

For development to be harmonious and inclusive and to avoid conflicts, all the communities living along the coast must also be made a part of the decision making process.

4.1 Coastal settlements

Settlements along the coast include fishing villages, towns and cities. India has a large number of coastal cities including the two megacities of Mumbai and Kolkata, and the Chennai Urban Agglomeration, which is fast reaching megacity status. Other large cities on the coast include Tuticorin, Cuddalore, Visakhapatnam and Puducherry on the east coast and Kochi, Mangalore and Surat on the west coast. Many of the port cities are also becoming industrial hubs and transforming into urban agglomerations. There are a number of smaller towns and villages located along the coast with populations largely dependent on agriculture and fishing.

According to the Central Pollution Control Board, 87 cities and towns located in the coastal areas of the country generate 5,560.99 MLD (million litres per day) of wastewater, which is almost 80% of their total water supply. This quantity is almost 33.37% of the total quantity of the wastewater generated by 644 class I cities and class II towns in the entire country. The volume of wastewater has increased more than two and a half times over the volume generated two decades ago. Out of this 78% is now collected, while during 1978 the collection was only 46%. About 58.50% of this is generated from the west coast. The State of Maharashtra contributes about 45% of the total wastewater generated by the coastal cities and towns, while the state of West Bengal comes second, contributing about 26%. Thus Maharashtra, West Bengal and Tamil Nadu generate almost 80% of the wastewater among the coastal states and union territories. Out of the 5,560.99 MLD of wastewater generated only 521.51 MLD receive various levels of treatment before being let out into coastal waters. Out of the total wastewater generated, 90.62% finds its destination into the coastal waters without any treatment. The coastal waters of Maharashtra state receive the greatest quantity of untreated municipal wastewater, to the tune of 2,382.64 MLD, followed by the coastal waters of West Bengal with 1,466.08 MLD from their respective cities and towns[1].

4.2 Coastal livelihoods

Fishing: According to the 2010 Marine Fisheries Census by the CMFRI[2], there are 3,288 marine fishing villages and 1,511 marine fish landing centres in the 9 maritime states and union territories. The total marine fisherfolk population is about 4 million in 8,64,550 families. Nearly 61% of the fishermen families are under

1 CPCB. Urbanisation & Wastewater Management in India. Parivesh, February 2005.

2 CMFRI, 2012. Marine Fisheries Census, released 2010. Cadalmin – CMFRI Newsletter, Apr-Jun 2012

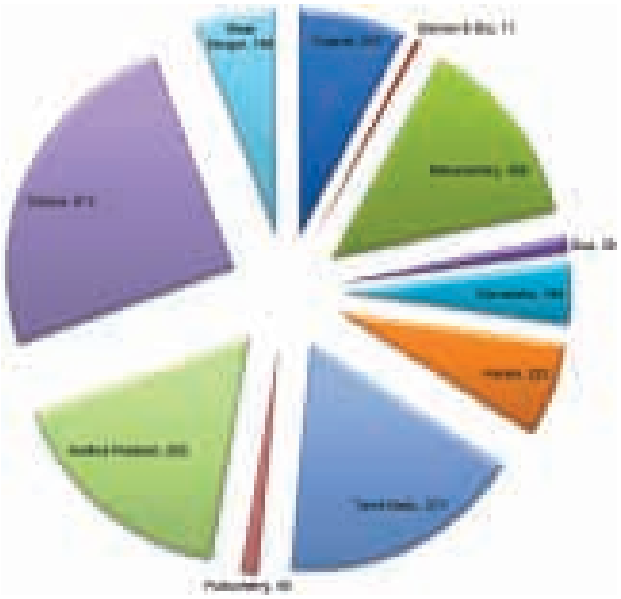


Figure 4.1: Number of fishing villages (CMFRI 2010)

BPL (Below Poverty Level) category. About 38% of the marine fisherfolk are engaged in active fishing, 85% of them working full time. About 63.6% of the fisherfolk are engaged in fishing and allied activities. It should be noted that the population density of fishing villages is usually much higher than other villages. For example, in Tamil Nadu[3] the population density of fishing villages was estimated at 1,338 per km^2 whereas the average coastal density was about 478 per km^2.

With high coastal and marine biodiversity, it is not surprising that **marine fisheries** are important all along the Indian coast. A significant proportion of the fish landings in India are from inshore waters. Most of the fishing continues to be small scale/artisanal, though in recent times close to 70% of the catch has been brought in by mechanized boats while providing employment to only 34% of the fishers[4].

The estimated marine fish landing of India during 2010 was 3.07 million tonnes, with 55% of the total catch being pelagic fish. The distribution of fish catch between west coast and east coast is 55:45. The gross revenue from the marine fish landings during 2009-10 at the point of first sales (landing centre) was estimated at Rs.19,753 crores, registering an increase of 14% over the previous year. The latest statistics from the marine fisheries sector show that there are 1,94,490 crafts in the fishery out of which 37% are mechanized, 37% are motorized and 26% are non-motorized. Out of a total of 1,67,957 crafts fully owned by fisherfolk, 53% are non-motorized, 24% are motorized and 23% are mechanized. Most of the non-motorized and many of the motorized craft are beach-landed. These statistics actually do not give information about the relationship between the marine fishing communities and the ocean, that has been built up over generations.

Fishing has largely evolved as a caste based activity, often exclusively involving in marine fishing and not related to the mainstream agrarian system. They have their own social and cultural governance structures. The community institutions, (such as the caste panchayats, peddalu, padu system, etc.) mostly organized along caste, kinship or religious lines, play an important role in resolving conflicts, besides regulating and allocating resource use, ensuring equitable access to resources and providing some form of social insurance. Most communities have evolved their own management systems over time to regulate human interaction with the resource, especially when large numbers of people bank on a limited resource, to avoid conflicts.

The Indian coastline can be delineated into 22 zones, based on the ecosystem structure and functions. The Indian boat type ranges from the traditional catamarans, masula boats, plank-built boats, dug-out canoes, machwas and dhonis to the present day motorized fibreglass boats, mechanized trawlers and gillnetters[5]. It must be noted that many of the traditional activities such as boat building and net making which were village based activities have been replaced by factory production, and fishing has become more technology oriented and technology based, and so perhaps not fully small scale any more. However, the lives of most fishermen continue to be small scale: their socio-economic conditions continue to be characterized by uncertainty, poverty and conflicts; and there is an ever-growing pressure from external forces, which traditional villagers do not even know, let alone understand[6].

Coastal Aquaculture: While brackish water farming in India has been practiced for centuries, it was confined mainly to the bheries (manmade impoundments in coastal wetlands) of West Bengal and pokkali (salt resistant deepwater paddy) fields along the Kerala coast. The naturally-bred juvenile fish and shrimp seed were trapped

3 Krishnakumar, A. Tsunami Exposes Chennai Fisherfolk's Poor Social Conditions. PRB On-Line: www.prb.org accessed 25 June 2005.

4 Sathiadas, R. Inter-sectoral Disparity and Marginalization in Marine Fisheries in India. Asian Fisheries Science 22 (2009): 773-786. http://eprints.CMFRI.org.in/587/1/AFS_Dr.Sathiadhas_paper4.pdf accessed 22 Aug. 12.

5 Fisheries and Fishing Communities of India. http://indianfisheries.icsf.net/ accessed 22 Aug. 12.

6 Salagrama, V. 2000. Small scale fisheries in India, does it exist anymore? Bay of Bengal News, March 2000.

in impoundments and allowed to grow to be harvested in due course. The development of commercial hatcheries in the early nineties, as part of the Blue Revolution, spurred the growth in shrimp aquaculture. The large potential for export and high profitability resulted in extensive areas being transformed into shrimp farms[7] by conversion of paddy lands and destruction of mangroves, especially in states like Andhra Pradesh[8]. Disease outbreaks resulted in closure of many of the farms and the land was rendered saline and useless. Shrimp farming continues to be problematic in the coastal areas, having both environmental and social impacts. Environmental issues include waste generation, conversion of agricultural land, salinization, degradation of soil, pollution due to the extensive use of drugs and chemicals, and destruction of mangroves. There were also problems of land alienation and denial of access due to the mushrooming of shrimp farms along the coast.

It was a public interest litigation filed by S. Jagannathan seeking to enforce the CRZ 1991 that made India's Supreme Court issue a directive[9] to close shrimp farms operating in the CRZ. Subsequently, the Coastal Aquaculture Authority Act, 2005 was enacted to regulate the activities connected with coastal aquaculture in coastal areas by prescribing guidelines, to ensure that coastal aquaculture would not cause any detriment to the coastal environment. Despite all this, illegal diversion of canals and illegal shrimp farms are still a major problem in places such as Nagapattinam district in Tamil Nadu[10].

About 91% of the shrimp farmers in the country have a holding of less than 2 ha, 6% between 2 to 5 ha and the remaining 3% have an area of 5 ha and above. Shrimp farming provides direct employment to about 0.3 million people and ancillary units provide employment to 0.6 – 0.7 million people[11].

Salt Manufacture: A second important coastal livelihood is salt production. India is the third largest producer of salt in the world with an average annual production of about 157 lakh tonnes, sea salt making up about 70% of the production in the country. Gujarat and Tamil Nadu are important sea salt producers. A majority of those who work in the salt pans are socio-economically backward and mostly illiterate, and are often migrant labour. Many of the salt pans are small holdings that are being swallowed up by 'development' activities of nearby towns and cities, as in the case of Mumbai, Maharashtra and Tuticorin, Tamil Nadu.

However, today salt production has increased unprecedentedly in some parts of India such as Gujarat. There are areas where mangroves have been impacted by increases in salt pan area (either through reclaiming or indirect impacts). In fact salt pans are being built by reclamation in the inter-tidal zone (Kachchh has an inter-tidal zone where the distance between high and low tide can be 5-10 kms).

PHOTO COURTESY: NCRC/BEDROC

Box 4.1 : Salt production process

Vedaranyam in Tamil Nadu follows a labour-intensive (around 10,000 people work in Vedaranyam's pans alone) traditional salt crystallisation process known as Visagam Brine Stagnation technique. This goes with the topography of the district – the coastal area is at a lower level than the sea – allowing for greater intrusion of sea water during high tide, minimising the use of motor pumps. The sun does the rest of it, condensing and crystallising the salt.

PHOTO COURTESY: NCRC/BEDROC

Workers manually flatten the floor with clay and sand to stabilise it. For every acre of salt crystallised, salt farmers who use ocean water as raw material need to prepare 11 acre of reservoirs. The saline water is then brought in through channels, passing through reservoir, condenser and crystalliser before it becomes salt. En route, gypsum and Epsom are collected as by-products. A lot depends on the preparation of the pits for their proper disposal. Text: http://www.indiatogether.org/2005/feb/eco-saltpans.htm

7 FAO. © 2005-2012. National Aquaculture Sector Overview. India. National Aquaculture Sector Overview Fact Sheets. Text by Ayyappan, S. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 1 June 2005. [Cited 23 September 2012]. http://www.fao.org/fishery/countrysector/naso_india/en

8 Hein, L. 2000. Impact of shrimp farming on mangroves along India's East Coast. Unasylva - No. 203. Vol. 51- 2000/4.

9 India -- S. Jagannath v. Union of India, WP 561/1994 (1996.12.11) (Aquaculture case). http://www.elaw.org/node/1974

10 Annie George, BEDROC. Pers. comm. 19 April 2012.

11 Shrimp Farming in India — Lessons and Challenges in Sustainable Development Aquaculture Authority News, Vol 1., No. 1, September 2002.

4.3 Coastal spaces

Coastal spaces refer to open lands in and around settlements that are used by the local community. In the case of the fishing community, the space is usually the sandy beaches. In the case of others, open lands, often classified as wastelands, form important grazing grounds for livestock, as even today free ranging is the most common way of maintaining livestock in rural areas.

PHOTO: NCRC/BEDROC, NAGAPATTINAM

Figure 4.2: Enabling a view of the sea

Fishing communities in India have customarily occupied the space closest to the sea; in fact other communities are traditionally loath to come between the sea and the fishing communities[12]. Their houses are built close to the shoreline to ensure that the sea is visible from their homes, the reason for this being that traditional methods (changing colour of the sea, direction of wind, etc) have been used to locate aggregating fish, based on which suitable nets are loaded into their craft as they proceed to the sea.

Overall, the space occupied by fishing communities goes into meeting the following four needs[13,14]:

• Common spaces for fishing livelihood: These are in the nature of common property and include beach or creek side to park/berth boats, auction/sale of fish, fish drying, mending nets and repairing boats. In places like Kachchh or Bengal, the seasonal places of stay for fishing should also be seen as an essential livelihood requirement. A community perception study by Rodrigues et al (2008)[15] came up with the following broad classifications of use of beach space by the community

- Boat landing and storage
- Boat repair and maintenance
- Catch drying (includes fish, seaweeds and conches)
- Pulling nets, laying and operating shore seine
- Storage of nets
- Making, mending and maintenance of nets (also cleaning and drying)

PHOTOS COURTESY: PHIL TOWNSLEY/ FIMSUL

Boats parked | Mending nets | Fish landing

Figure 4.3: On the beach

12 Vivekanandan, V. pers. comm.

13 Vivekanandan, V. “Legislation for protecting rights of fishing communities on the coast - some preliminary ideas”. Presentation made at an NCPC meeting, 2009.

14 Rodriguez, S. 2010. Claims for Survival: Coastal Land Rights of Fishing Communities. Dakshin Foundation, Bangalore, p42.

15 Rodriguez, S., G. Balasubramanian, M. P. Shiny, M. Duraiswamy and P. Jaiprakash. 2008. Beyond the Tsunami: Community Perceptions of Resources, Policy and Development, Post-Tsunami Interventions and Community Institutions in Tamil Nadu, India. UNDP/UNTRS, Chennai and ATREE, Bangalore, India. p 78.

PHOTOS: AHANA LAKSHMI

Drying fish (Chennai)

A boatyard (Nagapattinam)

Figure 4.4: Beach uses

- Spaces for support facilities: these may be in the nature of private property and include ice plants & cold storage, dry fish storage/godowns, marketing sheds, boat building or repair centres, motor service centres
- Residential space: In case of fishing hamlets, two broad scenarios may exist, both of importance. These include hamlets near the sea and fishermen going to sea from their homes and hamlets far away from the sea, with beach or sea side used for livelihoods only or for seasonal camp-sites using temporary structures for accommodation (e.g. Kachchh, Bengal).

PHOTOS: V.VIVEKANANDAN

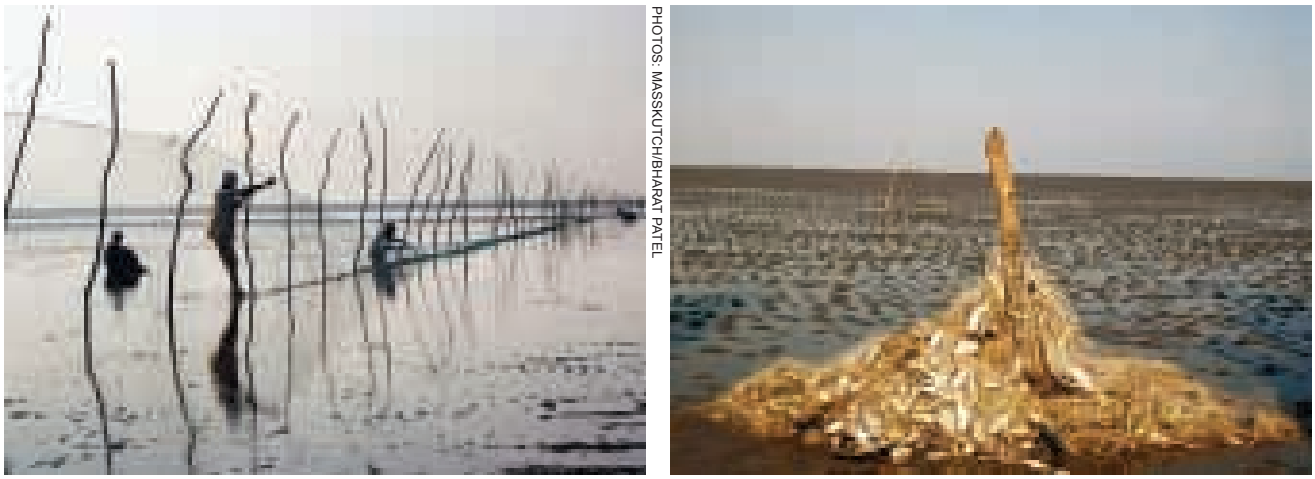
Figure 4.5: Temporary Housing, Randh Bandar, Kachchh, Gujarat

- Space for cultural needs: These include religious spaces such as temples, churches and mosques, wedding halls, community halls, play grounds and burial/cremation grounds.

PHOTO BY JOHN MANDEEN

Figure 4.6: Masimagam festival on the beach in Pondicherry

The coastal space utilized by the fishing community is not only the landward side (e.g. sandy beaches) but also the seaward side, specifically the intertidal zone in places like Gujarat where it is a very wide zone and highly productive in terms of fisheries as can be seen in the photographs below:



PHOTOS: MASSKUTCH/BHARAT PATEL

Figure 4.7: Fishing in the intertidal zone in Kachchh

Common lands/grazing lands: Many of the coastal (open) spaces are assumed to be open access in nature and hence free-for-all, a plausible reason why these spaces are under threat from new players in the coastal areas. In addition to the coastal spaces described above being used by the fishing community, there are grazing lands and commons that are used by agrarian and pastoral communities that live in coastal areas[16]. An article in Common Voices[17] says that livestock provides sustenance and food security to millions of pastoralists and small farmers in India, who use what is often termed 'wasteland' for grazing. It is estimated that while the livestock population in India has increased, permanent pasture and grazing land has been reduced by more than 50%. Simultaneously, the loss of forests has resulted in the loss of innumerable valuable species of both fodder and medicinal plants that form an important part of the diet of animals, apart from a loss to the biodiversity pool. Land classified as 'wasteland' has been earmarked/converted into biofuel plantations and industrial sites, which has resulted in conflicts because of the absence of policy that can inform development planning. In Gujarat, for example, 3,000 villagers forced the panchayat to cancel the resolution by which 400 hectares of the gauchar land (pasture) was given to Mundra SEZ, and declared that not an inch of the land would be given for the SEZ.

4.4 Coastal tourism

PHOTO: SVEN ULSA

Figure 4.8: Benaulim beach, Goa

Recreational tourism is a relatively new entrant but a fast growing segment with the increase in disposable incomes and strong advertising. Tourism in India today is the largest service industry, with a contribution of 6.23% to the national GDP and 8.78% of the total employment in India. Coastal resorts along the beach areas are steadily expanding, often at the expense of the local fishing communities whose access to beaches is often restricted.

A number of coastal locations in India have also been important from a religious as well as cultural point of

16 Salagrama, V. Coastal area degradation on the east coast of India: Impact on Fishworkers. Pp 143-155 in "Proceedings of the Indian Ocean Conference", ICSF & IOI, 2001.

17 Pastoral and Grazing Rights in Law: The Journey for Legitimacy. Common Voices, Issue 2: 21-27. http://www.dakshin.org/wp-content/uploads/2010/11/cv_2__final_low.pdf accessed 22 Aug. 12.

view. Each coastal state has important centres for religious, historic/cultural and recreational tourism. Important areas include Digha beach in West Bengal, Puri in Odisha, Visakhapatnam in Andhra Pradesh, Mamallapuram, Nagapattinam, Ramanathapuram and Kanyakumari in Tamil Nadu, Pondicherry town, Kovalam (beaches) and Kochi (backwaters) in Kerala, Gokarna and Udipi in Karnataka, the beaches of Goa, coastal forts in Maharashtra, and Somnath in Gujarat.

PHOTO: MYTHILI D.K

Figure 4.9: Ancient Mamallapuram temple structures on the beach

5. Coastal structures and their impacts

Moving away from the use of hard structures like seawalls and groynes to mitigate coastal erosion, "working with nature" is a principle being increasingly used worldwide today.

5.1. Armouring the coast

Sandy beaches are the dominant feature of most of the world's ice-free coastlines, and are increasingly threatened by coastal squeeze. The threat to sandy beaches is further aggravated because they are relatively poorly understood[1]. Because shorelines are dynamic in nature, changing constantly due to a variety of reasons, natural and anthropogenic, these are highly vulnerable to hazards: natural such as tsunamis, cyclones and storm surges as well as man-made hazards such as destructive developments, pollution and unsustainable coastal management.

Beaches are also areas of preferential investment and often require actions to ensure that such investment is protected. All over the world, until recently, the conventional response for coastal defence has been to armour the coast with hard structures ranging from seawalls and dykes to groynes and offshore breakwaters, with their primary purpose being to control erosion or prevent flooding. However, armouring of the coast has impacts on coastal morphology as it disturbs the littoral drift.

With the increasing extent of coastal armouring, there is concern about the cumulative impact of such structures on the coastline, considering the various adverse influences they have, which range from disturbing the longshore transport of sediment, restricting access to the beach and disturbing the aesthetic visual effects on the landscape[2] to impact on the ecology of the area. Of course, such effects are based on the type of coastline as well as the spatial and temporal scale of interventions.

5.2. Coastal structures

Seawalls are structures built parallel to the shore and at the transition between the low-lying (sandy) beach and the (higher) mainland or dunes. The height of a seawall often fills the total height difference between beach and

1 Schoeman, D.S., U.M. Scharler and A.J. Smit. An illustration of the importance of sandy beaches to coastal ecosystem services at the regional scale. In Bayed A. (ed.). Sandy beaches and coastal zone management – Proceedings of the Fifth International Symposium on Sandy Beaches, 19th-23rd October 2009, Rabat, Morocco Travaux de l'Institut Scientifique, Rabat, série générale, 2011, n°6, 139-140.

2 Stancheva, M, N. Rangel-Buitrago, G. Anfuso, A. Palazov, H. Stanchev and I. Correa. Expanding Level of Coastal Armouring: Case Studies from Different Countries. Journal of Coastal Research., Special Issue 64, 2011:1815-1819.

surface level of the mainland. In many cases, adjacent to the crest of a seawall a horizontal stone-covered part is present e.g. a boulevard, road, or parking places. At the time of construction a seawall is situated close to the position of the dune foot. The seaward side of the seawall is thought to be rather smooth[3].


PHOTO: SUNAINA MANDEEN

Figure 5.1: Seawall along Pondicherry's beach boulevard.

A revetment is, like a seawall, a shore-parallel structure. The main difference is that it is more sloping than a seawall, having a distinct incline e.g. 1:2 or 1:4, while a seawall is often almost vertical. The surface of a revetment might be either smooth or rough (seawalls are mostly smooth) and the height of a revetment doesn't necessarily fill the total height difference between beach and mainland[4].

A groyne is an active structure extending from the shore into the sea, most often perpendicular or slightly oblique to the shoreline. Catching and trapping part of the sediment moving in a surf zone (mainly in a longshore direction), as well as reduction of the sediment amount transported seawards, are the principle functions of the groyne[5].


PHOTO: SATISH BABU

Figure 5.2: Groyne under construction and a seawall along the Malabar coast

A breakwater is an offshore barrier built in or beyond the surf zone, usually made of stones or concrete, such as a groyne, that protects a harbour, wharf or shore from the full impact of waves. Breakwaters can also be detached from the shoreline. Like groynes, breakwaters catch and trap part of the sediment moving in a surf zone (mainly in a longshore direction).


PHOTO: SVEN ULSA

Figure 5.3: New Pier, Pondicherry

Piers, jetties and trestles are rather long structures with a horizontal deck on a series of piles extending perpendicular to the coast into the sea. Piers and trestles are constructed to serve as a landing place for vessels, as a recreation facility, as a measuring facility for coastal processes or as part of a sand by-pass facility.

Bridges and elevated roads in the coastal zone are usually built to link and carry people and materials across the body of water, in most cases across an estuary or a bay and in some cases across a part of the sea to join an island with the mainland.

3 van de Graaf, J. (2009). http://www.coastalwiki.org/coastalwiki/Seawalls_and_revetments.

4 Ibid.

5 Pruszak, Z. (No Date). Groynes. http://www.coastalwiki.org/coastalwiki/Groynes.

Marine outfalls and pipelines are built in the coastal zone to either draw or discharge liquids from or into the ocean. These are typically installed at power plants, which draw seawater for cooling and discharge the heated water back into the ocean. Pipelines are also used in desalination plants and other industrial units located along the coast. Marine outfalls are also used to dispose of municipal wastewater, though this is rarely practiced in India.

Various engineering activities likely to disturb the structure and functioning of the littoral zone are given in table 5.1.

Table 5.1: Engineered structures in the littoral zone[6]

	TYPE	EXAMPLES	IMPACTS
1.	Shoreline structures	Seawalls, embankments, revetments	• Directly encroach on intertidal zone from a landward direction resulting in physical reduction of intertidal area • Can cause disturbance to physical, biological and chemical structure of the immediate area • Can prevent intertidal zone from moving landward in response to wider coastal changes – resulting in coastal squeeze
2.	Cross-shore structures	Groynes, piers, harbour arms, tidal inlet jetties	• Alter structure and condition of intertidal zone by altering wave, current and sedimentary processes
3.	Flood structure	Embankments, flood walls	• Similar to shoreline structures • Activity can directly encroach on the intertidal zone from a landward direction, leading to a physical reduction in intertidal area • Can result in coastal squeeze

Morphological impacts of these structures on the littoral or longshore drift can result in[7]:

- trapping of sand on the upstream side of the structure, which takes sand out of the sediment budget, thus causing structural shore erosion along adjacent shorelines. In the case of large structures, there may also be initial erosion on the upstream side.
- loss of sand to deep water.
- trapping of sand in entrance channels and outer harbours.

5.3. Ecological impacts of coastal structures

The most significant impact of coastal structures on coastal habitats, particularly sandy beaches which have a significant net littoral drift, is the aggravation, increase and acceleration of coastal erosion down-drift (or down-current) by the structures – commonly known as the terminal groyne syndrome in the case of groyne fields – which leads primarily to destruction and loss of habitat. Coastal structures such as seawalls and groynes that are built on an ad hoc basis or for emergency protection, as is often the case, rarely address the root cause of the problem of erosion and thereby result in greater erosion.

The impact caused by the construction of such coastal structures is extremely significant, because it completely changes the morphology of the coastline by wiping out entire natural habitats, because erosion of land results in its disappearance. It is a total and complete annihilation of the coastal habitat. This is unlike the average destruction of natural habitat, where the flora and fauna may get destroyed but the land still remains and, if nothing else, is still available for regeneration or for a different land use. But in the case of coastal erosion, the coastal habitat is totally lost, including, flora and fauna as well as the land mass.

This is the case, for example, with the construction of groynes along the shores of Kottakuppam village in Viluppuram District, Tamil Nadu, north of Puducherry, that is described in case study (5.5) below. For every

6 Adapted from Change in the structure and condition of the intertidal zone: Impacts and causes. http://evidence.environment-agency.gov.uk/fcerm/en/SC060065/Decisiontree/Hydromorphologicalchanges/H20.aspx# accessed 15 August 2012

7 Mangor, K. Human Causes of Coastal Erosion. http://www.coastalwiki.org/coastalwiki/Human_causes_of_coastal_erosion Accessed 9 August 2012.

square metre of beach land that is reclaimed by the groynes on the up-drift side of the groynes, about 3 to 4 square metres of beach area is being destroyed and lost on the down drift side of the groynes. The groynes are clearly resulting in a net loss of coastal habitat in addition to having altered the habitat from a purely sandy one to a mixed rocky and sandy one.

In the case of breakwaters for harbours, sand by-passing that is supposed to be undertaken as a mitigation measure for prevention of erosion down-drift of the harbour through beach nourishment of the affected shore is rarely carried out, resulting in greater erosion of the coastline. Moreover, when harbour entrance channels get silted up due to poor maintenance dredging or lack of sand by-passing, larger dredgers are usually deployed to de-silt the harbour mouth. These larger dredgers can only dispose of the sand in deeper waters, thereby causing a deficit of sand from the sediment budget of that sediment cell. The impact on the coastal environment is once again increased erosion of the coast and loss of habitat.

The lifelong impacts of coastal structures on the coastal environment are most often greatly underestimated. Coastal structures that are considered by engineers and planners as part of infrastructure and built in the littoral zone, for example for shore protection, ports, harbours, power plants, desalination plants, etc., differ greatly from similar conventional “terrestrial” infrastructure such as bunds and embankments for roads which might resemble coastal structures in design and might even use similar construction techniques and materials. However, terrestrial infrastructure is surrounded by an environment which is physically static, especially when compared to the coastal environment, which is dynamic. Unlike similar terrestrial infrastructure, coastal structures instead interact with the surrounding environment, constantly modifying and impacting the physical environment that is in the vicinity each and every day of its existence, which is usually from several decades for smaller structures to a few centuries for larger ones.

Therefore any negative impacts that such coastal structures have on the environment, such as disruption of the littoral drift, are not one-time impacts, but last the life-time of the coastal structure, starting at the time of construction and continuing for so long as the structure exists. This fact is very often completely underestimated in the EIAs, in shoreline management plans or in the cost-benefit analysis of the development of coastal structures. Ignoring this aspect of the lifelong impacts of coastal structures very often results in the long-term destruction of an ever-increasing amount of the coastal environment.

Another less documented impact on biodiversity that is caused by the construction of coastal structures, particularly those that require an extensive use of rocks and boulders, is the destruction of other environments and habitats from which the rocks are quarried and extracted. Rocks and boulders are often quarried by destroying terrestrial environments and habitats that are located in the vicinity of the coast. The construction of coastal structures therefore not only results in the destruction of the coastal environment and habitats but also that of other directly or indirectly associated habitats. The environmental impact of the construction of coastal structures is therefore not an isolated one, but one that has cumulative, even multiplying effects.

Ecological impacts related to the introduction of infrastructure into shallow coastal waters have received relatively little attention, possibly for lack of relevant information. Recent studies on low-crested coastal defense structures have found them to have severe ecological impacts, such as:

- Erosion of beaches and sand dunes resulting in direct loss of habitat,
- Removing barriers that would normally isolate species,
- Favouring the spread of non-native species,
- Increasing habitat heterogeneity[8],
- Shrinking of habitat (erosion of sandy beaches) and
- Disproportionate loss of dry upper intertidal zones.

Of the above concerns, only the problem of non-native species appears to have been studied to a large extent. This could be because of their ability to change the habitat and influence succession, which could be identified by appearance or disappearance of species[9]. Impacts on species composition, abundance and trophic

8 Bulleri, F. and M.G. Chapman. The introduction of coastal infrastructure as a driver of change in marine environments. Journal of Applied Ecology 2010, 47, 26–35

9 Bax, Nicholas, Angela Williamson, Max Aguero, Exequiel Gonzalez and Warren Geeves. Marine invasive alien species: a threat to global biodiversity. Marine Policy 27 (2003) 313–323

structure of the invertebrate assemblages inhabiting marine sedimentary environments (soft-bottom benthos), particularly those living within the superficial layer of sediments, can also be expected[10,11].

In the case of seawalls, dry upper intertidal zones may be lost disproportionately, reducing the habitat types available and the diversity and abundance of macro-invertebrates. Predators, such as shorebirds, are likely to be affected by a combination of (i) habitat loss; (ii) decreased accessibility at high tides; and (iii) reduced prey availability on such beaches. Animals such as sea turtles would also find it difficult to lay their eggs[12,13].

When novel physical habitats are developed in areas subject to high influx of alien organisms, such as international ports, the combination increases opportunities for alien species to establish themselves. It must also be emphasised that breakwaters, seawalls, groynes, etc, provide vertical habitat in areas that may not have such options, and these could be used by invasive species for colonizing.

Limited studies have been carried out in India comparing biodiversity of artificial and natural seawalls on the Kerala coast[14]. They showed that many species occurring on natural rocky shores are either absent or found in differing composition in artificial seawalls, besides variations in the regeneration of communities in artificial systems. The study's authors point out that such protective armour may serve as a shelter for coastal biodiversity, and call for Habitat Enhancing Marine Structures (HEMS) that could be incorporated during the design of shoreline armour. Studies elsewhere have also suggested such options as inclusion of rock pools into the design of low crested structures, in addition to varying the size and packing of blocks[15].

5.4. Specific threats to coastal biodiversity - turtle habitats

Turtles are iconic species and have attracted extensive attention worldwide. Of the seven species of sea turtles found worldwide, five are found in waters of the Indian subcontinent. They inhabit a range of habitats such as seagrass beds and coral reefs, but come to sandy beaches to nest. Both along the west coast and the east coast, sandy beaches have been the nesting grounds for various species of turtles. The following are listed as the major threats to sea turtle habitats:

a. On the beach

i. Sand mining
ii. Beach erosion
iii. Beach armouring: These structures usually physically block female turtles from reaching suitable nesting sites, or if they do reach a site, may disrupt the hatchlings that emerge on the beach from finding and reaching the sea.
iv. Artificial illumination
vi. Highways and marine drives
vii. Exotic plantations
viii. Ports, harbours and jetties

b. In the offshore waters

i. Pollution
ii. Fisheries

c. Aquaculture

d. Tourism

10 Airoldi , L., M. Abbiati, M.W. Beck, S.J. Hawkins , P.R. Jonsson, D. Martin, P.S. Moschella, A. Sundelof, R.C. Thompson and P. Aberg. An ecological perspective on the deployment and design of low-crested and other hard coastal defence structures. Coastal Engineering. 52 (2005) 1073–1087

11 Martin, Daniel, Fabio Bertasi, Marina A. Colangelo, Mindert de Vries, Matthew Frost, Stephen J. Hawkins, Enrique Macpherson, Paula S. Moschella, M. Paola Satta, Richard C. Thompson and Victor U. Ceccherelli. Ecological impact of coastal defence structures on sediment and mobile fauna: Evaluating and forecasting consequences of unavoidable modifications of native habitats. Coastal Engineering. 52 (2005) 1027– 1051

12 Dugan, Jenifer E., David M. Hubbard, Ivan F. Rodil, David L. Revell and Stephen Schroeter, Ecological effects of coastal armoring on sandy beaches. Marine Ecology. 29 (Suppl. 1) (2008) 160–170

13 Dugean, Jenifer E. and David M. Hubbard. Ecological Effects of Coastal Armoring: A Summary of Recent Results for Exposed Sandy Beaches in Southern California. Puget Sound Shorelines and the Impacts of Armoring—Proceedings of a State of the Science Workshop.

14 Kumar, A. Biju and R. Ravinesh. Will shoreline armouring support marine biodiversity? Current Science, Vol. 100, No. 10, 25 May 2011, p. 1463

15 Moschella, P.S., Abbiati, M., Ĺberg, P., Airoldi, L., Anderson, J.M., Bacchiocchi, F., Bulleri, F., Dinesen, G.E., Frost, M., Gacia, E., Granhag, L., Jonsson, P.R., Satta, M.P., Sundelof, A., Thompson, R.C., Hawkins, S.J. 2005. Low-crested coastaldefence structures as artificial habitats for marine life: using ecological criteria in design. Coastal Engineering 52: 1053-1071.

5.5. Impacts of coastal structures on livelihoods

The majority of the coastal fishing communities, particularly those practicing subsistence fishery, depend on the naturally available beach-spaces. The beach-space is used for a variety of purposes, such as for habitation, parking of traditional fishing crafts, landing of fish catches, drying of fish, mending of nets and other gear, and for certain fishing operations like the deployment of shore seines, just to name a few.

The loss of beach space due to erosion and/or protection with the building of coastal structures has a very significant and direct impact on the livelihoods of those coastal fishing communities that depend on and use beach-space. Seawalls and revetments have the most significant impact on livelihoods because they block and restrict access to the sea and fully occupy the beach-space. All shore-based livelihood activities are severely affected and hampered by such structures.

Figure 5.4: Seawalled fishing hamlet Vaithikuppam, Puducherry

In addition to the loss of traditional livelihood opportunities such as fishing, the building of coastal structures that reduce the natural sandy beach-space also affects alternative livelihood opportunities that can be generated from activities that depend on sandy beaches. Beach tourism, for instance, is an increasingly popular activity which provides alternative livelihood opportunities and income generation. In the year 2007, beach tourism in the USA, generated US$ 320 billion in tax revenues for the Government[16]. The various livelihoods that can be supported by sandy beaches can be rapidly lost by the improper, unscientific and unsustainable development and deployment of coastal structures.

5.6. Case Study : Coastal structures of Puducherry and neighbouring Tamil Nadu[17]

Background:

Some of the first coastal structures built along the Puducherry coast date back to the 1800s when the fortified town of Pondicherry was built[18], presently also called the "Boulevard Town." Within this area, the quarter known today as the "French Town" was built over the sand dunes. Between 1856 and 1860[19], a masonry wall about 1.5 km long was erected along the shoreline immediately east of the beach road known as the "Cours Chabrol."

In 1862, construction began on a 250 m long pier (now known as the "Old Pier") which was completed three years later and inaugurated on 14th August 1865[20]. A severe cyclone in 1952 destroyed large parts of the pier[21], making it unusable. Remnants of the pier are still visible today. On the southern outskirts of the town, there was also a seawater intake line for cooling a power plant. Although this line has now been decommissioned, sections of the inlet structure are still visible during low tides.

The "New Pier" located on the southern end of the "Boulevard Town" was built relatively recently, in 1962. In the 1960s and 1970s, large granite boulders were dumped on the seaward side of the beach masonry wall along the beach road, presumably for reinforcement and protection against erosion. During that time, a rubble-mounded seawall was also built along the seaward boundary of the Pondicherry Distillery, located immediately to the north of the Boulevard Town, where the start of beach erosion had been observed.

In 1986-89, a commercial harbour was built in Puducherry at the mouth of the Ariankuppam River about 1.5 km south of the main town. This is the largest structure to be built in the littoral zone of the Puducherry coast. The harbour has an artificial entrance that consists of two breakwaters, the southern one about 370 m long, built at an angle from the shore and reaching about 280 m offshore, and the northern one perpendicular to the shore and about 150 m long. Rubble-mounded structures were also built on either side of the breakwaters to stabilize the harbour entrance.

The Central Water Power and Research Station (CWPRS, Pune), which studied the harbour layout, predicted that these breakwaters would disrupt the natural movement of sand – the long-shore littoral drift – which along this coast is estimated to be about 0.6 million cubic meters per year[22] towards the north and 0.1 million cubic meters per year towards the south – thereby causing large-scale and widespread erosion of the coast to the north of the harbour.

As the Pondicherry town and other densely populated areas lay to the north of the harbour, it was imperative to prevent any erosion of the coastline along those areas. Therefore, a sand by-passing and beach nourishment system was envisaged, designed and built as an integral part of the harbour infrastructure development in order to mitigate such erosion [23].

However, the Puducherry commercial harbour was a failed project, as commercial operations seldom took place. During most of its existence, and more so presently, the commercial harbour has been lying unutilised and is serving merely as a fishing harbour. Moreover, since the time of its construction, the sand by-passing system was ineffectively and seldom used. It was only after 1999[24] that some sporadic dredging of the harbour mouth

16 Houston, J. R. (2008). The economic value of beaches – A 2008 update. *Shore & Beach* , 22-26.

17 Case study prepared by Aurofilio Schiavina, PondyCAN, September 2012. Satellite Images Courtesy: Google Inc.

18 http://www.intachpondicherry.org/English/town.aspx

19 Weber, Jacques. (1988). Les établissements français en Inde au XIXe siècle, 1816-1914. Librairie de l'Inde Editeur, Paris.

20 Ibid.

21 National Institute of Ocean Technology. (2012). Management of Coastal Erosion along Pondicherry Coast: Status Report.

22 Central Water Power Research Station. (1978). Model Studies For the Development of Ariankuppam River Mouth for Harbour Facilities at Pondicherry. CWPRS, Pune.

23 Consulting Engineering Services Private Limited. (1982). Development of Pondicherry Port – Updated Project Report. New Delhi: Consulting Engineering Services Private Limited.

24 IOM, NCSCM, MoEF. (2011). National Assessment of Shoreline Change - Puducherry Coast.

was initiated, more as a measure to de-silt the harbour mouth than as an erosion mitigation measure. As a result of not operating the sand by-passing system as intended, the harbour breakwaters caused large-scale erosion of the coastline, stretching far to the north, including into the neighbouring State of Tamil Nadu.

In an attempt to limit the effects of this beach erosion, there has been a continuous process of construction, reinforcement and maintenance of seawalls along the shoreline north of the harbour. In all, about 7.5 km of the coast has been armoured. After the 26th December 2004 Indian Ocean tsunami, the seawalls along the Puducherry coast were extensively widened seawards. Additionally, a 50 m long groyne has been erected adjacent, along and to the north of the New Pier. Furthermore, two 30 m groynes have also been constructed either side of the Karavadikuppam Drain outlet north of the Boulevard Town.

During the last decade, the Government of Puducherry has, on several occasions, proposed to build other structures along the Puducherry coast, such as groynes for the increased armouring of the coast, breakwaters as mitigation against the effects of a new fishing harbour at Pudukuppam, and a deep sea water port at Puducherry. However, objections from members of civil society, the affected coastal communities and other governmental agencies such as the Ministry of Environment and Forests have so far prevented the construction of any such new structures along the Puducherry coast.

Shoreline change observations:

The changes and evolution of the Puducherry shoreline have been studied in detail only in recent times, notably by the Institute of Ocean Management[25] and the National Institute of Ocean Technology[26]. However, as these studies rely primarily on satellite imagery, they are limited to the evolution of the shoreline over the last four decades only.

It is generally acknowledged that the evolution of the Puducherry shoreline and the coastal environment is largely due to human induced factors, which date back at least to the times of the French occupation in the 1800s, when major structures e.g. masonry seawall, the Old Pier, etc, were built on what previously were coastal sand dunes.

In this regard, although the erosion of the coast at the Pondicherry Distillery in the 1960s was commonly regarded as a form of “natural” erosion, the effects of the man-made structures such as the Old and New Piers on the shoreline have never been studied in detail. There is significant circumstantial evidence indicating that the erosion of the beach at the Pondicherry Distillery in the 1960s was exacerbated by the construction of the New Pier e.g. by the coincidence of the two events, observed realignment of the shoreline and formation of a new headland at the pier structures. The formation of such headlands at the piers would have directly initiated a realignment and recession of the shoreline down-drift in the area of the Pondicherry Distillery.

Apart from this localized anomaly in the shoreline of the Puducherry coast, all other records available indicate that until the 1980s the shoreline and beach were relatively stable and did not exhibit any significant variation. This is illustrated in the figures below.

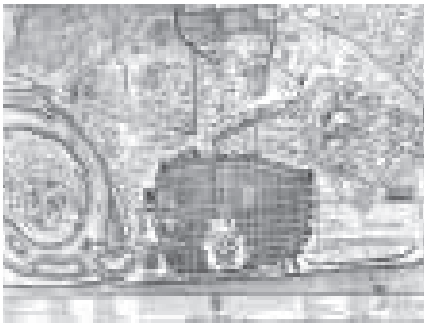


Figure 5.5: Fortified Town of Puducherry in the 18th century[27].

Figure 5.6: Shoreline & beach at Old Pier, ca. 1950[28].

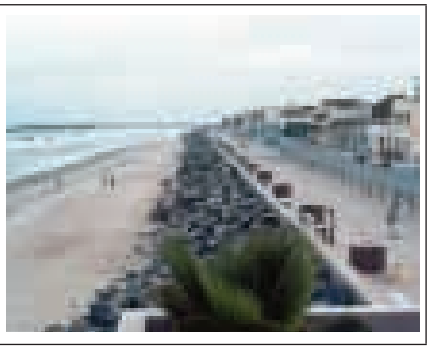


Figure 5.7: Shoreline & beach along beach road, ca. 1970[29].

Till the 1980s the Puducherry shoreline was relatively stable and unchanged.

25 IOM. (2011). National Assessment of Shoreline Change, Puducherry Coast. NCSCM, MoEF, GoI.
26 NIOT. (2012). Management of Coastal Erosion along Pondicherry Coast.
27 Source: http://fr.wikipedia.org/wiki/Fichier:Plan_de_la_ville_de_Pondich%C3%A9ry_au_XVIIIe_si%C3%A8cle.jpg
28 Source: Intach.
29 Source: Franz Fassbender

Figure 5.8: Satellite image of Puducherry coastline showing the predominantly linear profile of the coast in 1977.

IMAGE COURTESY: INSTITUT FRANCAIS DE PONDICHERY, G. MUTHU SANKAR, LIAG

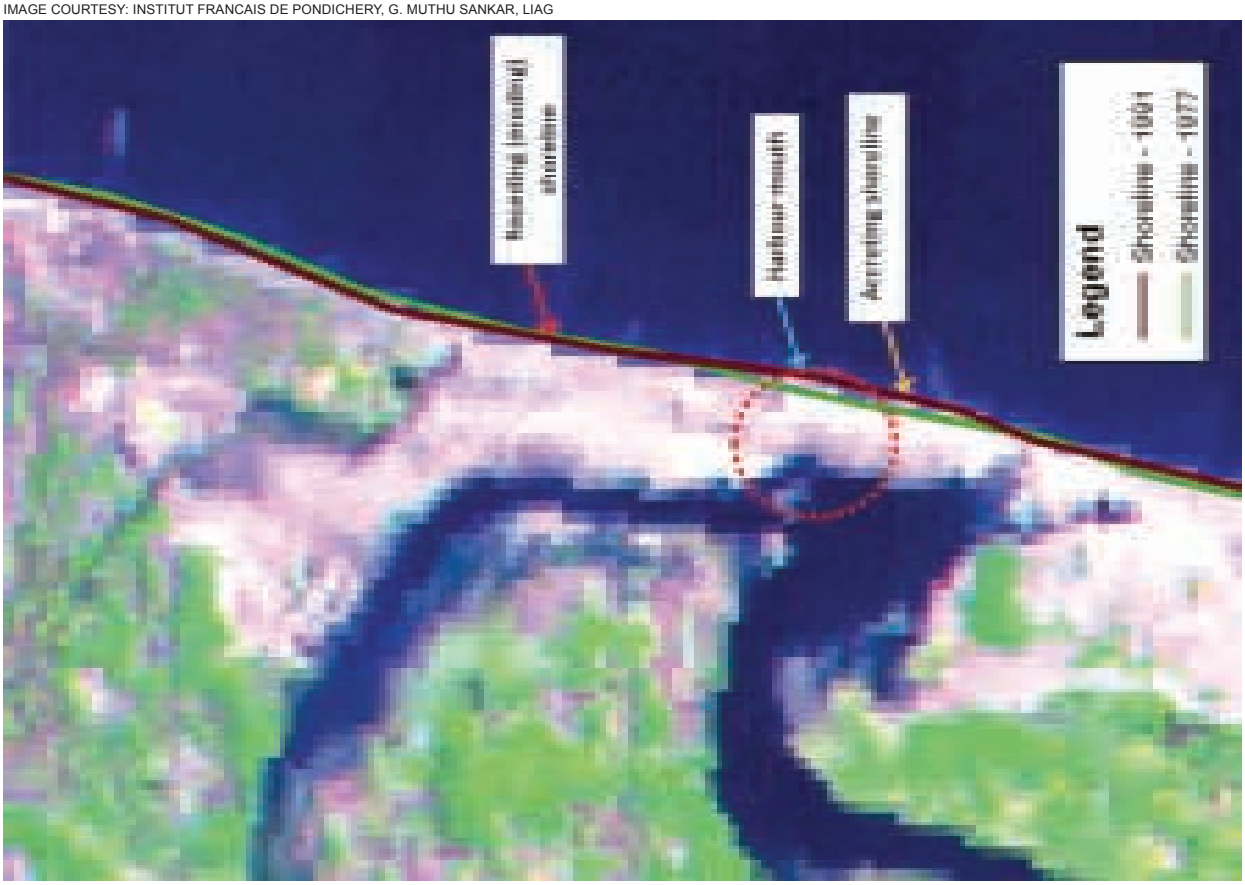


Figure 5.10: In 1991 already the shoreline on the north can be seen to have eroded, whereas to the south it has accreted.

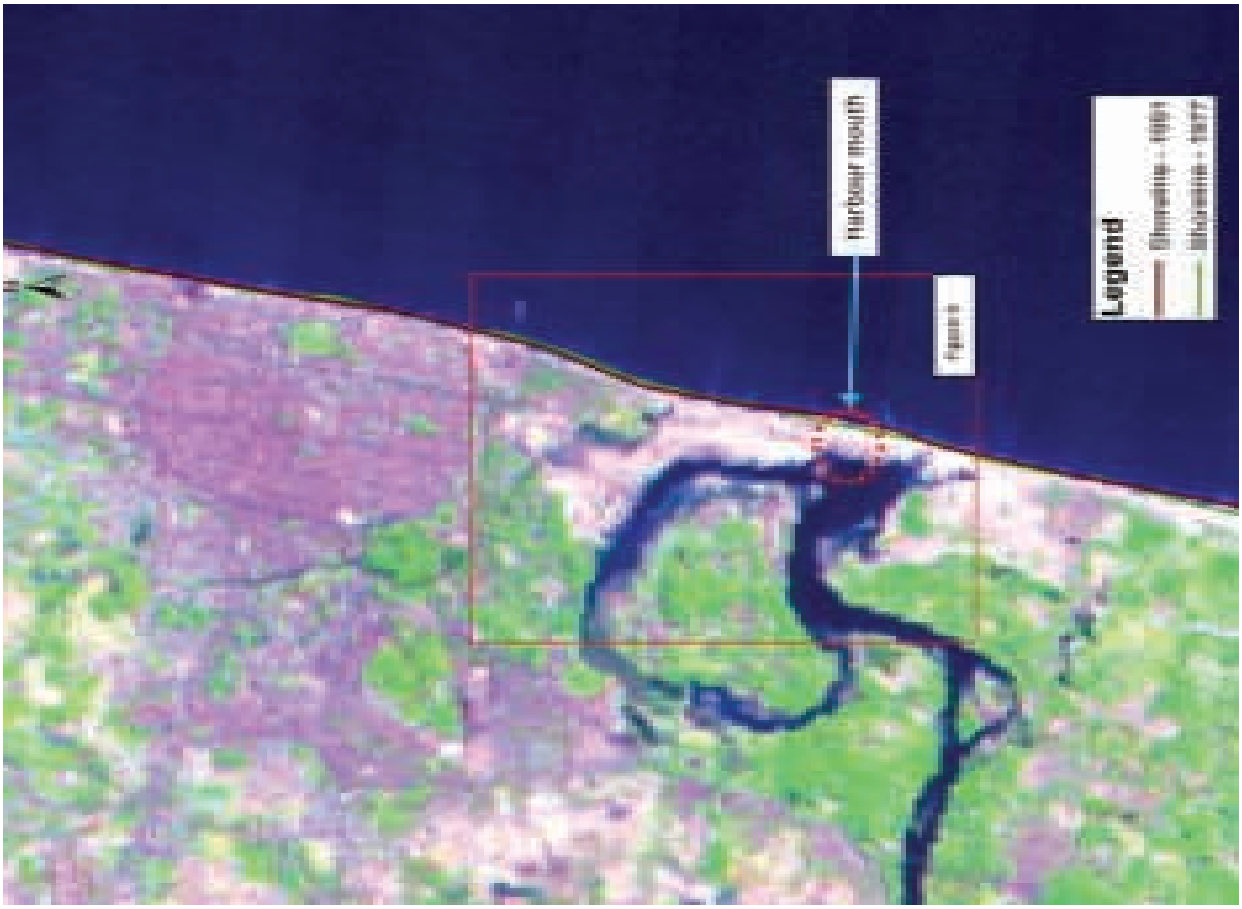


Figure 5.9 : Shoreline changes on either side of the newly built harbour are beginning to be visible in 1991.

IMAGE COURTESY: INSTITUT FRANCAIS DE PONDICHERY, G. MUTHU SANKAR, LIAG

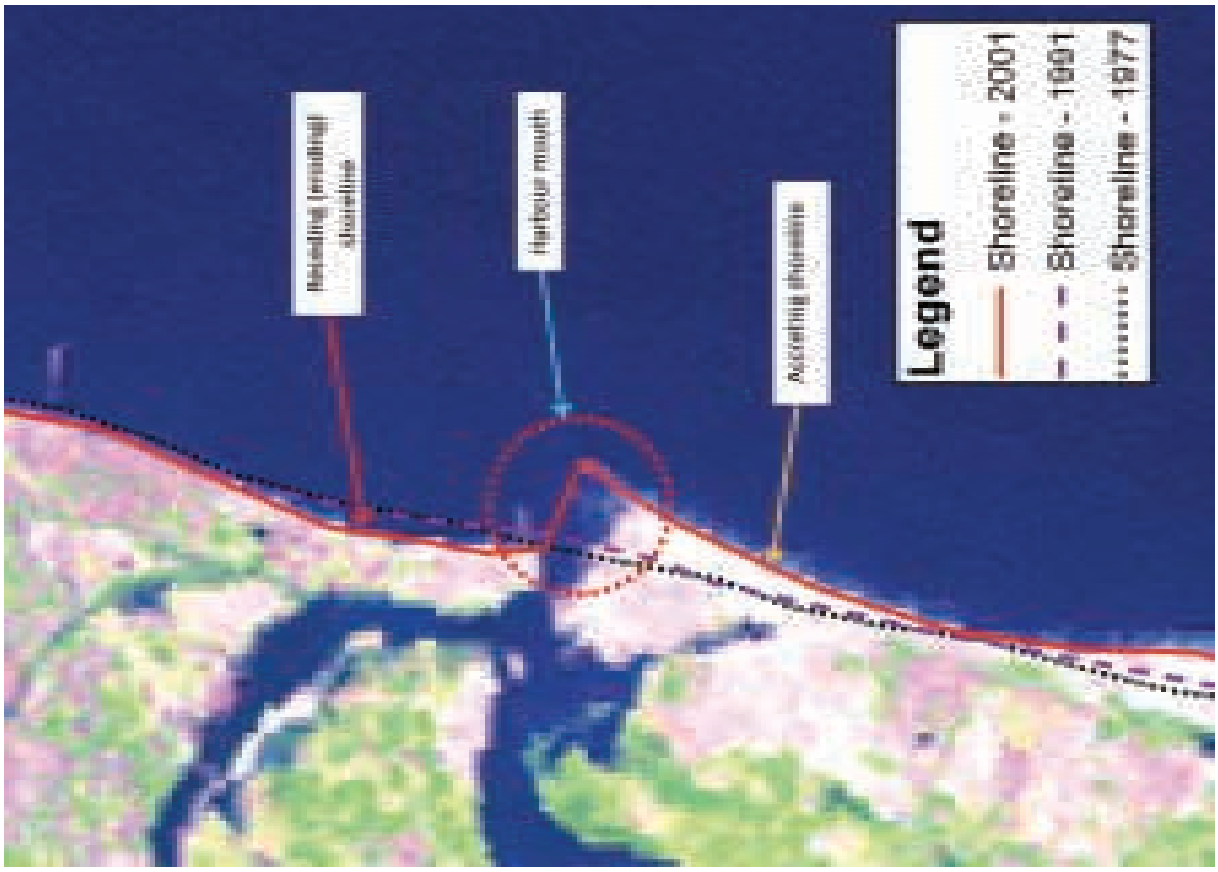


Figure 5.12: In 2001 the shoreline has undergone significant and extensive changes and the shoreline to north can be seen to have severely eroded, whereas to the south it has greatly accreted.

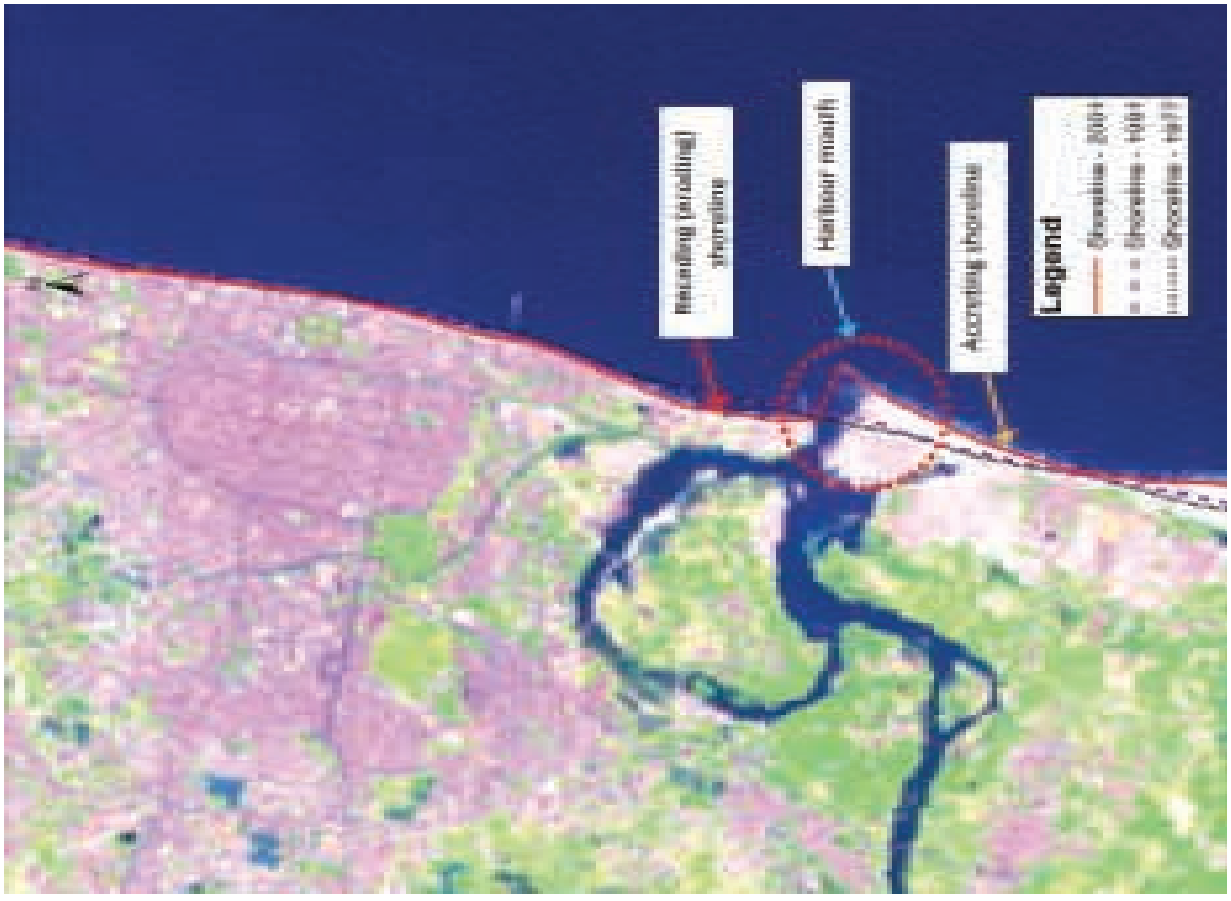


Figure 5.11: In 2001 the shoreline has undergone significant and extensive changes

Shoreline change caused by breakwaters:

In recent times, however, the two breakwaters at the mouth of the Puducherry commercial harbour have played the most significant role in the evolution of the Puducherry coastline. This can be clearly observed from the available remote sensing data collected during the years 1977, 1991 and 2001.

As a reference point, Figure 5.8 clearly shows that in 1977, before construction of the Puducherry harbour, the shoreline at the Ariyankuppam River mouth was predominantly linear. By 1989, when construction of the harbour was completed, shoreline changes had already been triggered, as can be seen in Figures 5.9 and 5.10, where a recession of the shoreline north of the harbour and an accretion on the south side can be detected. By 2001, this shoreline evolution is seen to be developed to a near-critical state, as can be seen in Figures 5.11 and 5.12. The wide beaches in front of Puducherry town and the fishing villages in between have all disappeared.

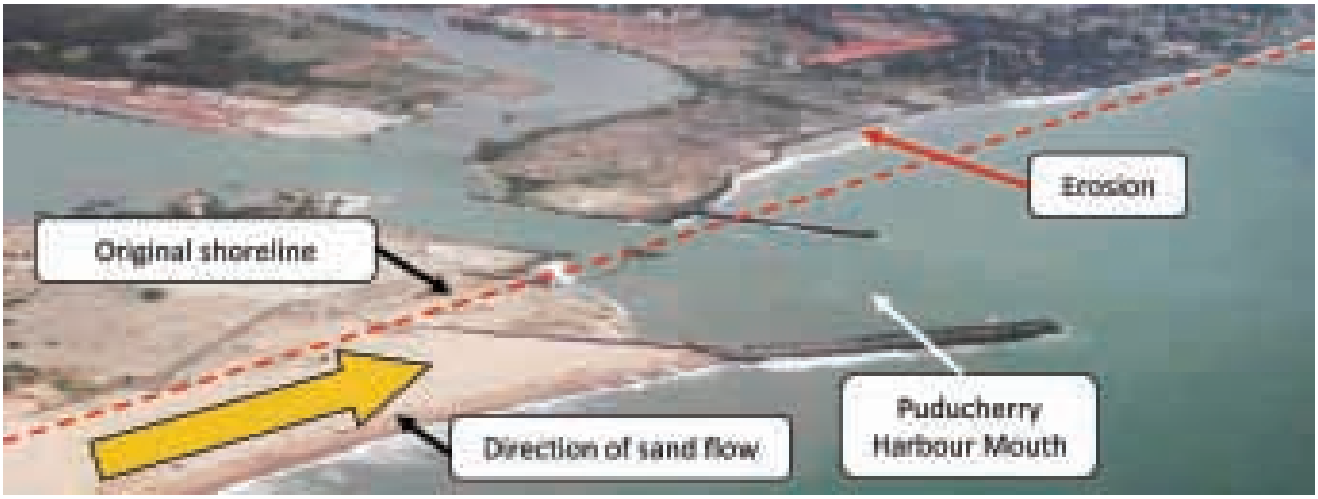
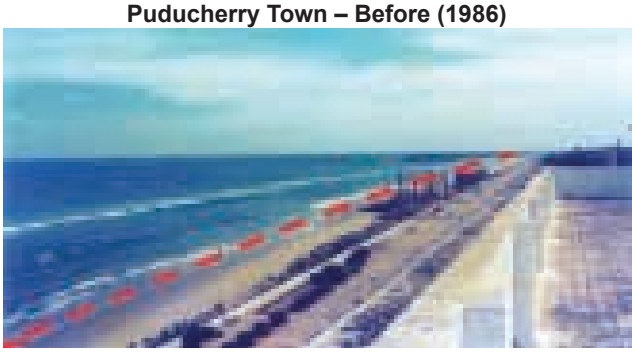


Figure 5.13: Impacts on shoreline caused by harbour

Puducherry Town – Before (1986)



Puducherry Town – After (2000)

Figure 5.14: Impacts on shoreline caused by harbour - Puducherry town

Soudanikuppam – Before (2000)

Soudanikuppam - After (2002)

Figure 5.15: Impacts on shoreline caused by Harbour – Soundanikuppam

Starting from the Puducherry harbour and going north, about 7.5 km of the coast in both Puducherry and neighbouring Tamil Nadu has been consequently armoured to reinforce the shoreline.

Impacts on coastal environment caused by seawalls:

Starting from the Puducherry harbour, about 7 km of the coast has been armoured with seawalls as a protection measure.

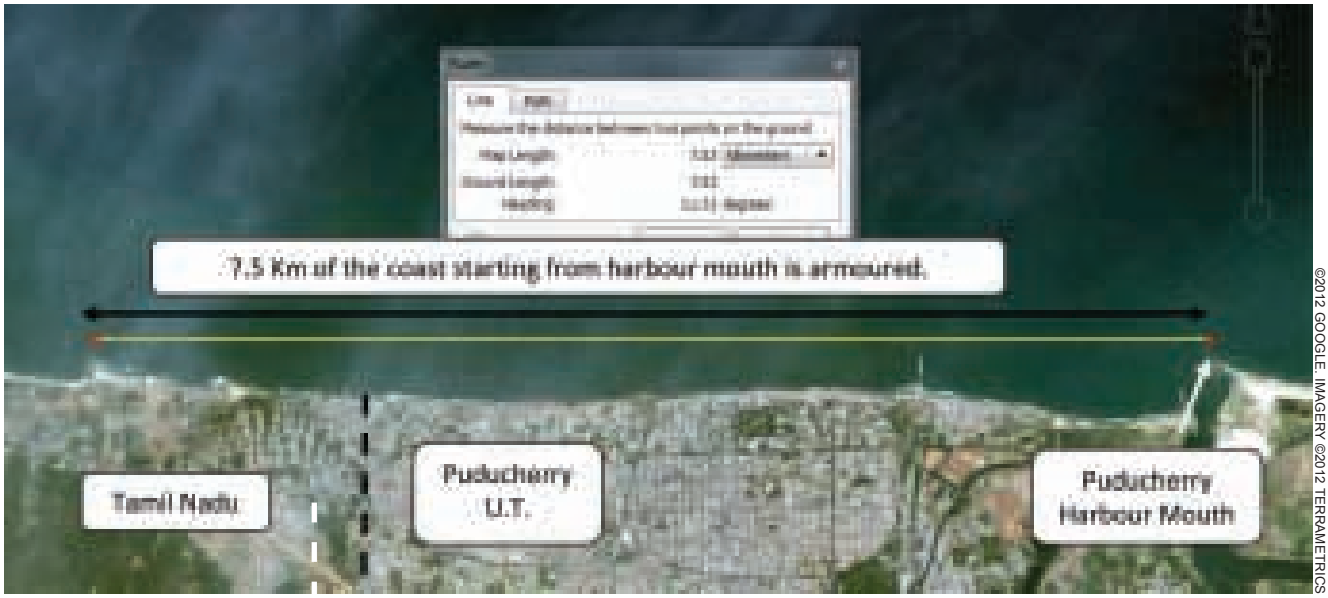


Figure 5.16: Armouring of the Puducherry coast

Seawalls diffract waves which carry sediments offshore resulting in further erosion.

Yellow arrow: sediment movement.
Purple arrows: wave diffraction

Groynes retain some sand but deflect all the surplus sand to deeper areas offshore causing erosion.

Yellow arrow: sediment movement

Figure 5.17: Sand movement

A study by V. Srinivas and R. Ali (2002)[30], that compared satellite imagery taken in March 1999 and May 2001 of the Puducherry coastline to the south and north of the Puducherry harbour, found that the affected coastline

30 Srinivas, V. and R. Ali, 2002. Coastal erosion in Pondicherry: A GIS study. FERAL, Pondicherry.

had suffered a net loss of beach (surface) area of about 9 hectares per year during that time. More significantly, the coastline to the north of the harbour, which has suffered severe erosion, had lost 22 hectares per year during the same period.

PHOTOS: AUROFILIO SCHIAVINA

Figure 5.18: “Le Café” building collapsing into the sea due to coastal erosion

Shoreline change caused by seawalls:

There is broad consensus that seawalls are detrimental to adjacent beaches and are passively responsible for narrowing of the beaches in front of them[31]. In the case of the seawalls built along the Puducherry-Tamil Nadu coastline, the armouring of the coast has, in turn, accelerated the process of erosion by trapping sediments under them, deflecting sediments offshore, and therefore further reducing the availability of sand on the downstream side of the shore and the littoral zone.

As a result of the construction of seawalls along about 7.5 km of the Puducherry-Tamil Nadu coastline, the sediment budgets have been disturbed, and sandy beaches have completely disappeared and been replaced by seawalls. The armouring of the shoreline is also having several secondary impacts on the coastal environment.

Shoreline change caused by groynes:

As seawalls built to protect the eroding coast were found to hinder and block access to the sea, particularly to those traditional fishermen who were using the beach to launch, land and park their fishing crafts, the Tamil Nadu government opted to armour sections of the coast with groynes. To date, a series of 7 groynes have been built along the affected coast of Tamil Nadu neighbouring that of Puducherry.

Figure 5.19: Series of 7 groynes built along Tamil Nadu coastline, north of Puducherry.

31 Pilkey, O. H. (1988). Seawalls versus beaches. Journal of Coastal Research, SI, 4 , Pp. 41-64.

The groyne field was built over a period of two years, starting sometime between February and September 2005. At first, smaller groynes were built towards the south. Subsequently, larger groynes were built to the north of Thandirayankuppam.

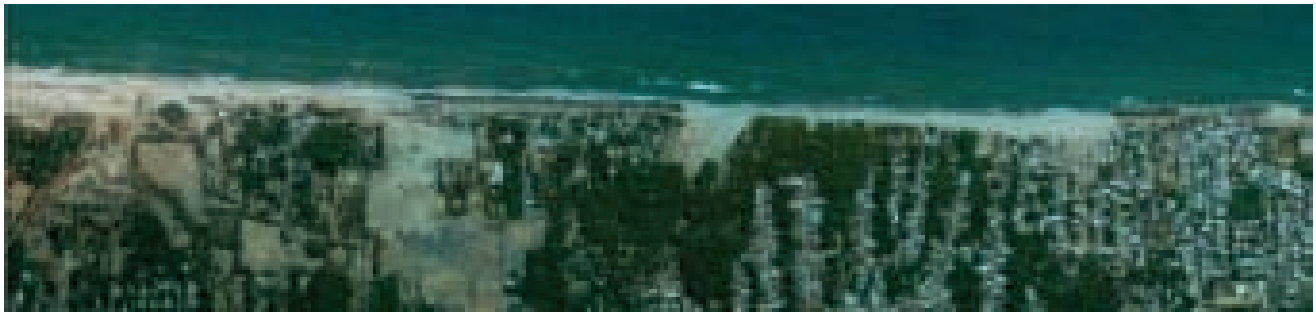


Figure 5.20: 18th February 2005: no groynes built yet.

Figure 5.21: 17th September 2005: first groynes built towards south.

Figure 5.22: May 2007: the last groyne, the largest one - about 170 m long – was built to the north of Thandirayankuppam.

The reasoning of the agencies promoting such schemes is presumed to be that the area immediately south of the groynes would encourage accretion and formation of a sandy strip which would enable the fishermen to park and launch their vessels. However, as these groynes are designed specifically to interrupt and trap sand mobility along the littoral zone, a direct consequence of this policy has been the sand starvation of the areas north of the groynes field. Such consequences were well known and understood at the time of the design and construction of these groynes, and have subsequently been proven to occur by documentary evidence.

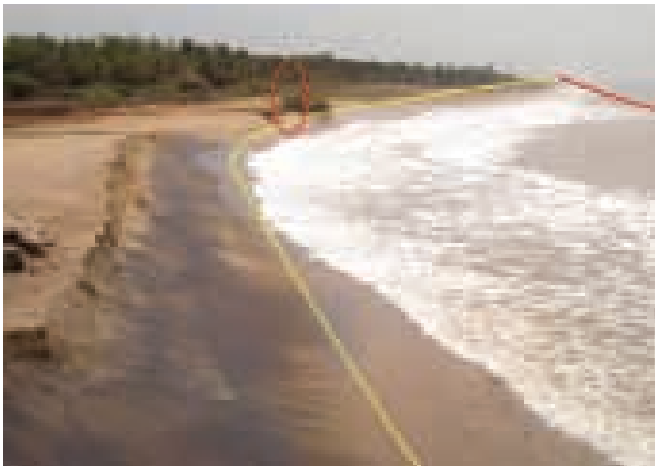
The impacts on sediment flows and the resulting shoreline change and erosion along the shore to the north has been documented photographically on the ground and remotely with satellites as well as by field measurements.

Benchmark: April 2007

9th May 2007

6th June 2007

28th June 2007



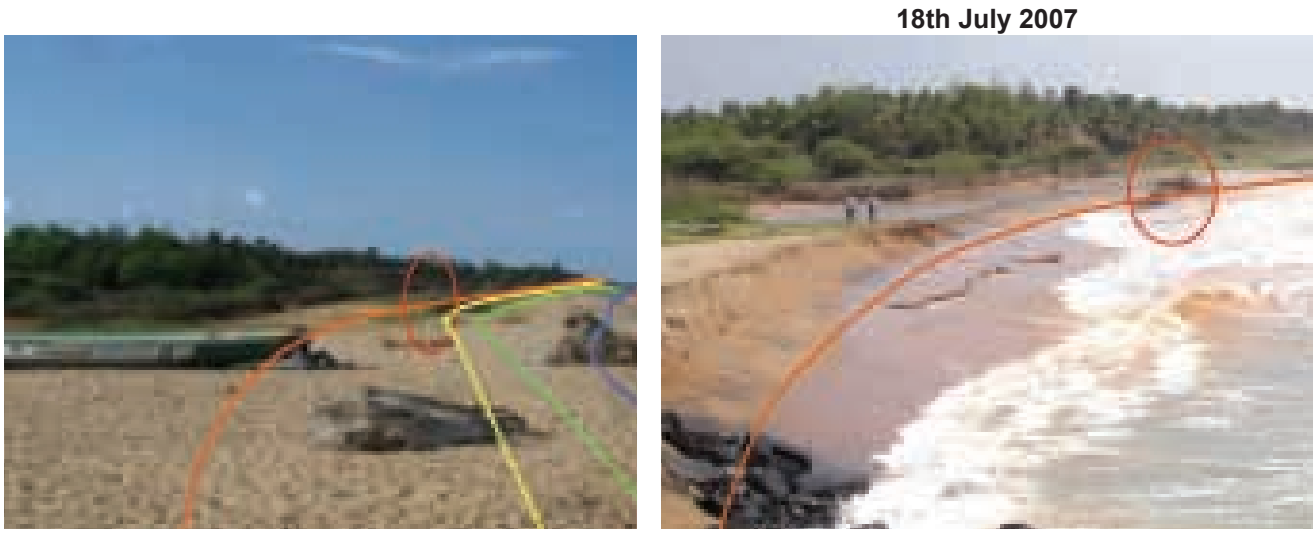


Figure 5.23: Changes of the shoreline caused by groyne field

The shoreline change in a 12 week period is summarized in the illustration below.

Figure 5.24: Shoreline change north of groyne field

The construction of the groynes has resulted in some accretion to the south of the groynes but far greater erosion to the north. From the time of construction of the groynes in 2005, the area of beach surface gained and lost up to July 2011 during a 6 year period has been measured from satellite imagery (Google Earth).

Over the given 6 year period, the satellite imagery shows a visible change in the shoreline (erosion) down-drift (i.e. to the north) of the groyne field up to a distance of 3 km and beyond, the most significant and noticeable change having taken place in the first 3 km stretch from the groynes. To the south of the groyne field, there is no shoreline change (accretion) beyond a distance of 2 km from the northern-most groyne.

In order to compare the performance of the groyne field, measured as beach-space formation versus beach-space destruction, an area of 3 km on either side of the last, northern-most groyne has been taken into consideration. The area of beach surface gained from accretion along the 3 km stretch of the coast to the south of the northern-most groyne has been found to be approximately 29,000 m^2. On the other hand the area of beach surface destroyed and lost along the 3 km stretch of the coast to the north of the northern-most groyne has been found to be 102,000m^2.

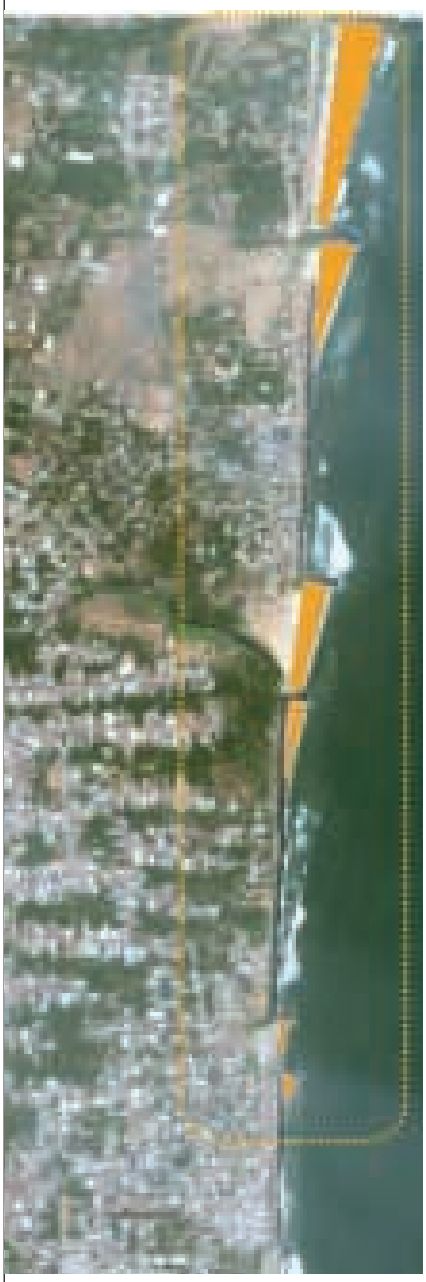
Area of beach surface gained: 29,000 m^2	Area of beach surface lost: 102,000m^2	Net loss beach surface: 74,000 m^2
		

Figure 5.25: Erosion & accretion

These results indicate that since the groynes were built in 2005 there has been a net loss of 74,000 m2 (72%) of the beach area along this 6 km stretch of the coast up to the year 2011. On an annual basis, for every 4,800 m2 of beach area gained, about 17,000 m2 of beach area was lost. In other words, for every square metre of beach gained, about 3.6 m2 of beach area was destroyed and lost.

Field measurements of the beach width (from the shoreline to a fixed benchmark) were carried out at the "Reception" and "South End" areas of the Auroville Quiet Healing Centre by members of this centre over the period 2006 to 2009.

Figure 5.26: Auroville Quiet Healing Centre (green area)

The first measurements were taken in the year 2006 before the groyne field was built, up to the year 2009, when the fence of the property, used as the bench mark, was washed away. The measurements taken are given in table 5.2 and figure 5.27 below:

Table 5.2: Beach width measurements at "Quiet"

Measurements of beach width (metres) at Auroville Quiet Healing Centre.				
	Reception Area			
Period	**2006**	**2007**	**2008**	**2009**
Apr/May	69	(60)	49	35
Jun/Jul		48		34
Aug/Sep	58	36	22	21
Difference	**11**	**(24)**	**27**	**14**
	( ) = extrapolated trend			
	South end			
Period		**2007**	**2008**	**2009**
Apr/May			45	43
Jun/Jul			24	14
Aug/Sep			7	0
Difference			**38**	**43**

The period April to September only is taken into consideration as this is the period of peak beach sediment movement northwards[32] causing the maximum change of the shoreline.

32 CWPRS. (1978). *Model Studies For The Development of Ariankuppam River Mouth for Harbour Facilities at Pondicherry.*Pune: Central Water Power Research Station

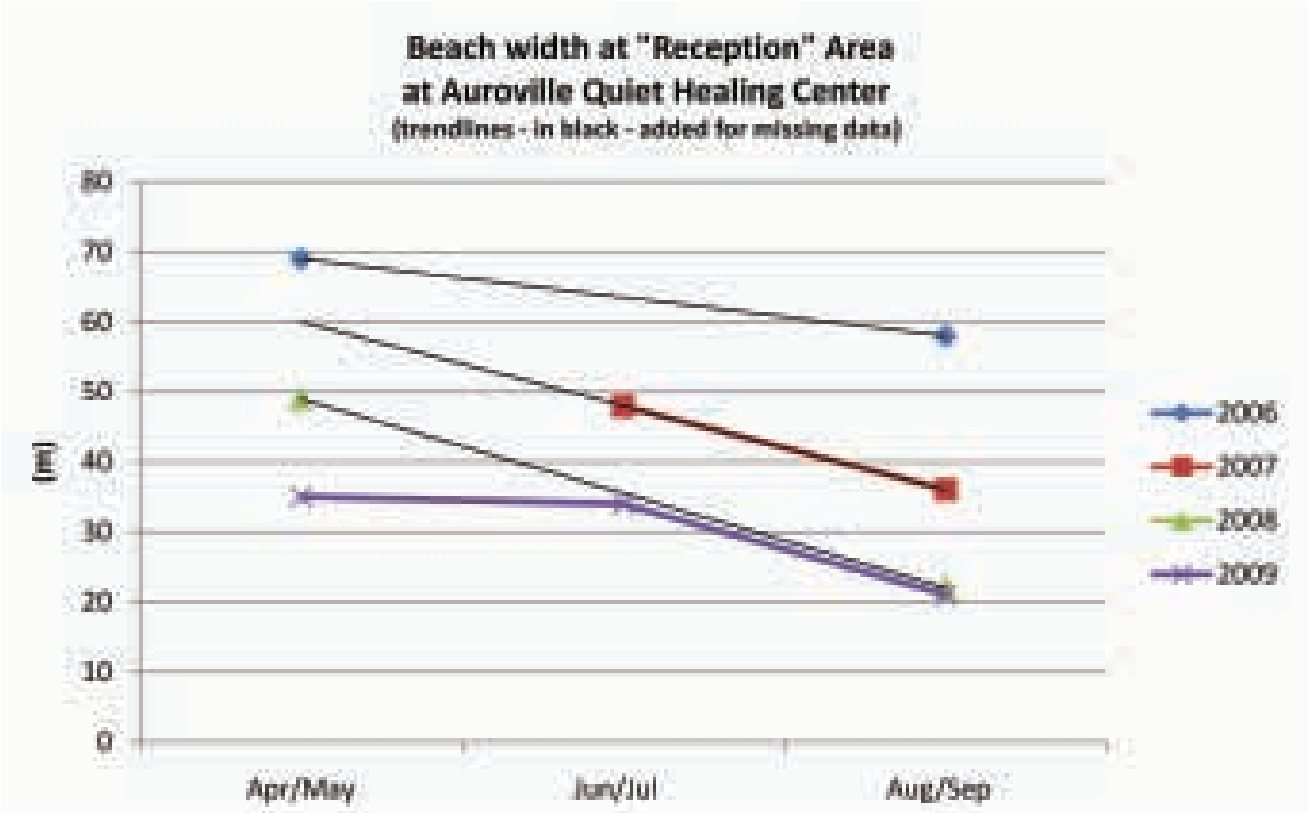


Figure 5.27: Changes in beach width at Quiet Healing Centre

In the year 2006, before the groynes were built, the seasonal variation of the shoreline was about 11 m during that year. It should be noted that this section of the shoreline was already in a disturbed state, as it was in the "shadow" of the previously built seawalls as well as in the "shadow" of the Puducherry harbour. Therefore, the seasonal variations captured in these measurements are likely to be greater than the background natural variations.

In the year 2007, during the period June/July to August/September alone, the beach width had reduced by 12 m. By extrapolating the trend line to April/May, it is estimated that the reduction over the summer of 2007 would have been in the order of 22 m. This is corroborated with the data and trend of the shoreline change in 2008.

In the years 2008 and 2009, during the period June/July to August/September the beach width had reduced by 27 m and 15 m respectively.

With reference to the seasonal shoreline variation 11 m that was recorded in the year 2006 (table 5.2) i.e. before the groynes were built, the variation of shoreline changes recorded along the shore at the "Reception" area had significantly increased to about 27 m in 2008, an increase by 250% when compared to the shoreline variation in the year 2006, and an increase to 14 m in 2009, an increase of about 30% when compared to the year 2006.

With reference to shoreline change measurements at the "South End" area listed in table 5.2, in the year 2008 and 2009, during the period between April/May the beach width had reduced by 38 m and 43 m respectively.

The above data indicate that the shoreline to the north of the groyne field became significantly more variable and therefore unstable. The groyne field has therefore had a significant detrimental impact on the natural stability of the shoreline.

Although there are no quantitative assessments of the net sediment loss north of the groyne field, the satellite imagery below clearly shows that groynes caused re-alignment of the shoreline, redirecting and dispersing the sediment into the offshore and deeper zones, causing the sand to be "lost" in the subaqueous zones. This phenomenon can be clearly observed from the sediment plumes visible in figure 5.18, which show movement in an offshore direction, increasing in size and distance from the shore in relation to the size of the groyne.

Figure 5.28: Loss of sand to offshore regions

Impacts on coastal environment caused by coastal structures:

As a result of the severe and widespread erosion caused first by the Puducherry harbour due to lack of sand by-passing and later compounded by the associated seawalls and groynes, 7.5 km of sandy beaches have completely disappeared, and beaches up to a distance of 15 km downstream of the harbour mouth are showing signs of erosion; in particular the sand bar is deepening, the sand grains are getting coarser and the beach slope is growing steeper. Additionally, the armouring of the shoreline is having several secondary impacts on the coastal environment.

The coastal areas that have been worst affected by the human-induced erosion are the town of Puducherry and the coastal villages Vembakirapalayam, Kuruchikuppam, Vaithikuppam and Solai Nagar in Puducherry and Soudanikuppam, Nadukuppam, Thandirayankuppam, Chinnamudaliarchavadikuppam and Bommayarpalayam in Tamil Nadu (Fig. 5.29)

Figure 5.29: Coastal settlements affected by coastal erosion caused by harbour

Puducherry: 1) Vembakirapalayam, 2) Puducherry Town, 3) Kuruchikuppam, 4) Vaithikuppam and 5) Solai Nagar
Tamil Nadu: 6) Soudanikuppam, 7) Nadukuppam, 8) Thandirayankuppam, 9) Chinnamudaliarchavadikuppam and 10) Bommayarpalayam
Source: Satelite imagery: Google Earth. Art work: PondyCAN.

The following are the impacts that have been observed along the affected Puducherry-Tamil Nadu coast:.

Physico-chemical:

- Loss of physical barriers of the beach, sand bar and dunes has resulted in seawater intrusion both over the land and in the underground aquifers. Coastal lands, property and houses have been inundated. Shallow, coastal aquifers have become salinised.
- As a result of the loss of physical barriers which absorb and dissipate energy of the waves the coastal environment has become more vulnerable to natural calamities, especially to tsunamis, cyclones, surges and sea-level rise.
- The intrusion of saltwater into the aquifers is causing water scarcity, which has enormous environmental, biological and social implications.

Ecological and biological:

- The disappearance of the beach and the armouring of the shoreline is causing a direct loss of natural habitat of the sandy beach ecosystem. The beaches and the intertidal zones have shrunk or disappeared. The dunes have been eroded or lost completely.
- Species such as the endangered Olive Ridley sea turtles that nest along the Puducherry-Tamil Nadu coastline, and require and depend on sandy beaches for laying their eggs, are the most visibly affected. In addition to the loss of the beach spaces, the obstacles presented by armouring of the shoreline pose one of the most significant threats to sea turtle populations[33].
- Numerous other species, both floral and faunal, that live and depend on sandy beach habitats, such as ghost crabs, bivalves, sea worms, shore birds, dune grasses, etc, are also affected. Several of these organisms are part of the complex food chain of the coastal and marine ecosystem, and their disappearance has an effect on the entire food chain.

Socio-economic:

- The traditional fishing villages of Vembakirapalayam, Kuruchikuppam, Vaithikuppam and Solai Nagar in Puducherry and Soudanikuppam, Nadukuppam, Thandirayankuppam, Chinnamudaliarchavadikuppam and Bommayarpalayam in Tamil Nadu have completely lost their sandy beaches. These places had wide sandy beaches, ranging from 100 to 200 metres wide. Presently, except for the northernmost village of Bommayarpalayam, which still has a narrow strip of beach barely 10 m wide, all other places have completely lost their beaches. As the fisher folk from these coastal villages practice shore-based fishing (either literally fishing from the shore, or using the shore as a fish landing site), all of their shore-based fishing activities i.e. fish drying, mending nets and other equipment, boat repairing, etc, have been severely affected. Thus the livelihood of several thousands of traditional fisher folk[34] has been directly affected by the erosion caused by the Puducherry harbour and the associated coastal structures.
- Unlike the traditional agrarian communities in India, the majority of the traditional fishing communities do not own the land or the water bodies upon which they depend for their livelihood. At best, the traditional fishing communities enjoy a traditional right on the use of the land as well as the aquatic space on which their livelihood activities depend. As a result of the human-induced loss of these coastal spaces, the fishing communities find it difficult to secure compensation for the loss of their property and livelihoods. Furthermore, the fisher folk traditionally possess few skills other than fishing. Thus, they become environmental refugees with very few opportunities available to them to start a new life.
- The shrinkage and loss of public and common beach space has often resulted in clashes between neighbouring coastal communities. The deterioration of the coastal environment often also results in the deterioration of law and order within the coastal communities.
- Beach space can increasingly provide alternative livelihood opportunities to coastal communities, as beach and eco-tourism and various related activities gain popularity. Loss of beach spaces therefore also deprives the coastal communities from the sort of alternative livelihood opportunities that they could otherwise fall back on in times of hardship.

33 Mosier & Witherington, n.d.

34 The Hindu, (2008), 7,000 houses in coastal villages at the mercy of weather changes., Jun 03, 2008.

The degradation and loss of the sandy, coastal environments in Puducherry and neighbouring areas of Tamil Nadu caused by human-induced erosion and the armouring of the coastline is therefore clearly impacting the natural environment as well as the coastal communities in several ways. These impacts are only increasing with time, and larger areas of the coast and numbers of people are being affected. There is an urgent need to address these impacts and mitigate them. The process of environmental and socio-economic degradation needs to be reversed.

Coastal structures, the result of a lack of integration in coastal management:

Due to the lack of integration between sectors, government departments, state and central governments, the problem of coastal erosion has been compounded by the development of coastal structures. The root cause of the severe and widespread erosion of the coast in the Puducherry-Tamil Nadu region clearly lies with the harbour. It is the disuse of the commercial harbour, the lack of revenue generation by the Port Department and other administrative problems which have resulted in the poor maintenance and operation of the harbour mouth and the absence of dredging and sand by-passing. All these have caused the severe and widespread erosion of the coast.

While the Port Department is indisputably responsible for the management of the dredging and sand-bypass systems at the harbour, it does not hold administrative responsibility for the protection of the coast per se. The control of coastal erosion and its management lies with another government department, the Puducherry Public Works Department (PPWD). The PPWD however has been adopting protection measures of the coast without taking into account that the root cause of the erosion lies with Puducherry harbour. Rather than tackling the root cause of the erosion by alleviating the blockage of sand by sand by-passing at the harbour, the PPWD has instead focused all its attention and efforts on micro-managing the symptoms, and has been building coastal structures to armour the Puducherry coast. However, the construction of coastal defenses along the Puducherry coastline has been unable to mitigate the erosion of the coast. On the contrary, it has aggravated the problem by further restriction of the natural sand movement that maintains the long term stability of these beaches. With the armouring now extending all the way to the state boundary with Tamil Nadu and beyond, the problem of the erosion of the coast triggered by the Puducherry harbour has now also been foisted on the State and Government of Tamil Nadu.

Responsibility for protection of the Tamil Nadu coastline rests with the Tamil Nadu Public Works Department (TNPWD). As with the PPWD, the TNPWD has also ignored the root cause of the erosion lying at the Puducherry harbour mouth. Rather than targeting a solution to re-enable sand by-passing at the Puducherry harbour mouth, the TNPWD has also adopted a defensive approach of coping with the symptoms and built even more and larger structures to armour and attempt to protect its own coast.

However, all efforts of armouring the coast so far have predictably only resulted in greater erosion and destruction of the coast. The cumulative impacts of the breakwaters at the harbour, the seawalls and groynes have resulted in an increasing disruption of the natural movement of sand along the coast, thereby accelerating the rate, extent and severity of coastal erosion.

Rather than being proactive and anticipating the problem of coastal erosion, all the concerned agencies have been, at best, reacting to the problem after it has occurred, and action has been taken only when the entire width of an eroding beach has completely disappeared, and when the properties and homes of those living right along the shore have been damaged or destroyed. Even then, the emergency coastal defense measures have been piece-meal, ad hoc and aimed at providing immediate relief at a very localised level. These measures, however, do not take into account the wider coastal environment, and fail to address perspectives of the various stakeholders and the natural processes. Rather than adopting macro solutions required to protect and prevent the destruction of the wider coastal areas, the solutions to date have only managed to transfer the same problems to other communities further along the coast.

Figure 5.30: Fragmented, intermingling coastlines of Cuddalore, Villupuram and Puducherry districts.
Source: Satelite imagery: Google Earth. Additional art work: PondyCAN

In the particular instance of the Puducherry and adjacent Tamil Nadu region, the problem is further compounded by the fact that the coastlines of Puducherry and Tamil Nadu inter-mingle with each other. Pockets of Puducherry and Tamil Nadu coastline alternate each other, starting to the south of Puducherry in the Cuddalore District

Figure 5.31: Disruption of littoral drift caused by groyne resulting in erosion.
Aerial panoramic view of Banyan beach and groyne at Thandirayankuppam, 16 September 2012

of Tamil Nadu and continuing all the way across Puducherry and into the Villupuram District to the north of Puducherry.

The nature of the geography, geomorphology and coastal processes along the Puducherry-Tamil Nadu coastline absolutely demands an integrated approach to the management of the coast, both between State Governments and across Government agencies. Experience from the last two decades – since the Puducherry harbour was built – has clearly shown that the unplanned, un-integrated and ad hoc proliferation of coastal structures has only resulted in the creation and propagation of man-made disasters that are increasing with time.

Concluding remarks:

The coastal structures that have been built along the Puducherry shoreline, particularly the breakwaters, the seawalls and groynes that were built after the 1980s, had – and still continue to have – a significant, direct and visible impact on the physical, biological and social environments of this coastline. The direct loss of natural habitat and sandy beaches is affecting the biodiversity as well as the livelihoods and well-being of coastal communities along the Puducherry coast.

In order to reverse some of these impacts, the erosion of the coast should not be treated as a phenomenon that needs to be fought against, but an impact that needs to be mitigated. By controlling and mitigating the problem of erosion caused at the Puducherry harbour mouth, the natural movement of sand can be restored so that the beaches will be nourished, maintained and sustained. There will therefore be little need to armour the coast with seawalls and groynes, as the formation of natural beaches and dunes, as well as the seasonal littoral movements of the sand, will largely provide the required protection and beach nourishment.

The restoration of the natural movement of sand along the shore will not only facilitate restoration of the coastal environment, beaches, dunes and sand bars but will also simultaneously restore the livelihoods of the coastal communities that depend on the coastal environment.

Fighting against the sea by attempting to defend and armour the coastline is a battle that cannot be won. Rather, this struggle requires imaginative solutions that exploit and channel the existing natural macro-processes that have generated the beaches over millennia in the first place. Enabling the natural sand littoral mobility to bypass the localized obstruction at the Puducherry harbour mouth would enable these natural processes to re-establish themselves and subsequently maintain a viable sandy coastline in the affected areas. However, this approach will require an integrated commitment by all the stakeholders and, in particular, by the key enablers (Puducherry Port Department, PPWD and TNPWD), who have the means and the responsibilities to ensure an effective and sustainable solution to the problem.

6. Coastal development and impacts

6.1 Large projects in the coastal zone

Large projects in the coastal zone typically occupy many tens of hectares, sometimes even hundreds. They have an impact much beyond the area that they actually occupy. Some of them straddle the land and water area, such as ports and harbours. Others such as power plants use coastal resources e.g. sea water in large quantities, and hence are located not too far from the coast. In addition, many new power plants located near the coast have captive jetties for coal as well.

Special Economic Zones are commercial areas that have special tax and other facilities, supposedly to encourage marketing. However, in most cases such large projects are increasingly at the expense of local agriculture: large areas are undergoing land use change from agriculture to industry, apart from wreaking havoc on the life of the local communities as well as the ecology of the region[1].

Most large coastal developments involve the construction of coastal structures in the littoral zone. Some of these structures are built as a part of the development, such as the breakwaters when a harbour is being developed. However, very often other previously unplanned structures get added to a large development. For instance, seawalls and revetments often get built subsequent to the construction of a harbour, because the breakwaters that are built for the harbour trigger off a process of coastal erosion which in turn is controlled with the use of additional structures like seawalls, revetments and groynes. The various impacts caused by coastal structures have already been presented in detail in Chapter 5.

Until recently, the concept of mitigating the impacts caused by large developments was not part of the planning process. It is only recently that impacts are required to be mitigated. However, there are large development projects such as the majority of India's ports and harbours that were built prior to the introduction of the laws that make mitigation measures compulsory. None of these large development projects are equipped to mitigate the environmental impacts that they are causing. Of equal concern is the lack of implementation of mitigation measures, even in developments where mitigation of impacts was incorporated in the original planning of the project. The case of the Puducherry harbour is a classic example, where the elaborate sand by-passing system that was set up during the time of construction of the harbour in order to mitigate the erosion of the coast was seldom used. The

1 Muralidharan, C.M and R. Ramasubramanian, 2009. Impact of Special Economic Zones & Coastal Corridor on Children and Coastal Communities in Andhra Pradesh. A study for Academy of Gandhian Studies and Plan International. Unpublished report.

effective mitigation of impacts in the case of development of large projects is an area that needs to be closely and carefully looked at.

In the following sections, an overview of the large projects in the coastal zone is provided.

6.2 Ports and harbours

A **harbour** is a place where ships, boats and barges can seek shelter during stormy weather, or are stored for future use. Harbours can be natural or artificial. A natural harbour is surrounded on several sides by prominences of land that provide tranquil conditions. The same is sought to be created by the construction of breakwaters, seawalls or jetties. A **port** is a location on a coast or shore containing one or more harbours where ships can dock and transfer cargo or people to or from land. Port locations are selected to optimize access to land and navigable water for commercial demand, and for shelter from wind and waves.[2]

Even when a port has a natural harbour, the preference for larger ships has resulted in the extension of the harbour seawards by building requisite protective structures like breakwaters. However, these structures have often been built without full understanding of the littoral drift patterns and have resulted in changes in the adjacent shoreline, especially erosion. Simultaneously, the water spread of ports as well as their increased depths has enabled ships of larger capacity to berth. This means that dredging to maintain channel depths is an absolute necessity. This requires the removal of large quantities of sediment and relocating it to reclaim land which could be used for port activities.

MODIFIED FROM GOOGLE EARTH

Figure 6.1: The natural inner harbour and the artificial outer harbour, Visakhapatnam

All activities have environmental and social impacts. These impacts can be traced to

1) **Location** - Many ports are **located** in or near creeks which may have environmental issues (e.g. location near turtle nesting sites, requirement of creek diversion/closure) and social issues (proximity to fishing hamlets, fishing grounds).
2) **Construction -** Activities in ports take place on both the landward side and in the water area. Breakwaters, groynes and other coastal structures are constructed in the offshore area to create tranquil conditions.

2 Port. http://en.wikipedia.org/wiki/Port accessed 3 August 2012.

Capital dredging is carried out initially to create the required draft, while maintenance dredging has to be carried out to ensure that the requisite depth is maintained. The construction of breakwaters and dredging of navigation channels for port development interferes with the long-shore littoral drift. The main impact of the port development on the physical environment of the coast is accumulation on the up-drift side of the long-shore drift, but more importantly, erosion of the down-drift side of the coast. The impact is most prominent and severe on coastlines having high rate of long-shore sediment transport, such as in the case of the majority of the coastal stretches of the eastern coast of India.

3) **Operation -** Wastes may be generated due to ship-related factors, cargo-related factors and land transport activities. During operations accidents often occur, such as spillage of polluting materials. Lack of implementation of planned mitigation measures is also a cause of impacts during operation.

Overall, two major sources of impacts of port development in the marine environment – specifically related to the littoral zone and littoral transport – are said to be due to breakwaters and related coastal structures and dredging[3]. Different case studies reveal large differences in coastal geomorphology and also reveal the major influence of port development on the coastal regions. As such, it is necessary to understand the coastal processes and predict the likely effects before undertaking any coastal project.

PHOTO: AHANA LAKSHMI

Figure 6.2: Breakwater being extended – Royapuram Fishing Harbour, Chennai

Ports are also high on the **socio-economic impacts** that they cause. On top of the list is the **displacement** of the local population (often fishers living on community property without proper land rights, or subsistence agriculturists), who may be moved inland and may lose their lands or access to the sea. Restriction of access (fishing boats are not usually allowed inside a port area) and ship traffic are major problems. Loss of beaches can also occur due to positioning of breakwaters that result in shoreline erosion, and seawalls and groynes placed to protect the shoreline may result in restriction of access to beaches, especially for those using shore seines and beach-landed craft. Many ports also promise provision of a fishing harbour, but this can result in

3 Kudale, M.D., 2010. Impact of port development on the coastline and the need for protection. Ind. J. Mar. Sci. 39(4): 597-604.

small traditional craft having to compete with trawlers and mechanized vessels. As the preferred location of ports is creeks and estuary mouths, they are often located near important fish breeding areas.

In many areas, tidal creeks are used for navigation. Tidal inlets are frequently regulated and fixed by inlet jetties and are frequently dredged to enable navigation. This results in sand accumulation on the up-drift side and lee-side erosion along the down-drift coastline, unless special precautions are taken. When the sand accumulation on the up-drift side reaches the tip of the jetty, the sand will start to bypass, and this will cause sedimentation in the inlet. Normally the sand does not pass the dredged channel and therefore does not nourish the lee side beach[4].

6.3. Power plants

A Thermal Power Plant (TPP) is steam driven: usually coal is burnt in a furnace to boil water to generate steam which drives a turbine to generate electricity. At the other end of the steam turbine is the condenser, which is maintained at a low temperature and pressure. A constant flow of low-temperature cooling water in the condenser tubes is required to keep the condenser shell (steam side) at proper pressure and to ensure efficient electricity generation. Anthracite coal is the largest source of fuel used. The major components of a TPP are the power system and associated facilities, which may include the cooling system, stack gas cleaning equipment, fuel storage handling areas, fuel delivery areas, solid waste storage areas, worker colonies, electrical substations, transmission lines, etc.

Coolant water: For cooling the condenser tubes, large quantities of water are used. The efficiency of power plants ranges from 35-45%, which means that large amounts of waste heat are transmitted into the environment through the coolant water at temperatures 6-12 degrees higher than the ambient water[5]. The discharge of coolant water is usually of the order of 20,000 m^3 daily [6,7]. The heated water is normally discharged back to the water source i.e. river, lake, estuary or the ocean, or the nearest surface water body, though it does not immediately mix with the source/receiving water body. Discharge of coolant water can have negative impact on marine biodiversity. Seasonal variation of water temperature is reflected in the natural fluctuations in growth, which has an impact on the marine environment. Continuous discharge of heated effluent results in reduction in variation in thermal differences between summer and winter, and consequently in reduced natural seasonal cyclic changes in the species composition and density. Raising of sea surface temperature due to global warming is likely to have an additional effect as well. Higher temperature can favour growth of blue green algae, resulting in harmful algal blooms[8]. Marine copepods are sensitive to thermal stress; the ability of some copepod species to survive higher temperatures may result in abnormal community succession as well[9].

The second major problem of TPPs is the production of ash. Ash is composed of modified coal mineral matter i.e. primary compounds of silicon, aluminium, iron, calcium, manganese, potassium, sodium and titanium, which form a matrix for traces of compounds of other metals. Ash composition depends on the coal properties, combustion technology and combustion conditions. Particulate material such as fly ash or particulate matter in gas streams from the combustion process are captured by electrostatic precipitators or fabric filters (FF – also called baghouses). Ash is also extracted from the bottom of the boiler (bottom ash). This is then transported to ash ponds as a slurry, in dense phase (paste), or dry. Fly ash from some power stations is used for blending with cement. Depending upon the efficiency of the TPP and ash content of coal, over 250 metric tonnes of coal per hour are used in a 500 MW TPP. Thermal power plants are notorious for pollution due to coal dust and ash. Fly

4 Mangor, K. Coastal Hydrodynamics and Transport Processes.http://www.coastalwiki.org/coastalwiki/Coastal_Hydrodynamics_And_Transport_Processes Accessed 6 August 2012.

5 Jiang, Zhi-Bing, Jiang-NingZeng, Quan-Zhen Chen, Yi-Jun Huang, Yi-Bo Liao, Xiao-QunXu and Ping Zheng.Potential impact of rising seawater temperature on copepods due to coastal power plants in subtropical areas. Journal of Experimental Marine Biology and Ecology 368 (2009) 196–201.

6 Kulkarni, V.A., V.S. Naidu and T.G. Jagtap.Marine Ecological Habitat.A case study on projected thermal power plant around Dharmantar creek, India. J. Environ. Biol. 32 (2011): 213-219.

7 Pitchaikani, J. Selvin , G. Ananthan and M. Sudhakar. Studies on the Effect of Coolant Water Effluent of Tuticorin Thermal Power Station on Hydro Biological Characteristics of Tuticorin Coastal Waters, South East Coast of India. Current Research Journal of Biological Sciences 2(2): 118-123, 2010.

8 Krishnakumar, V. An overview of thermal pollution with special reference to Indian Coastal Waters.Encology 9(4) 1994: 6-9.

9 Jiang, Zhi-Bing, Jiang-NingZeng, Quan-Zhen Chen, Yi-Jun Huang, Yi-Bo Liao, Xiao-QunXu and Ping Zheng.Potential impact of rising seawater temperature on copepods due to coastal power plants in subtropical areas. Journal of Experimental Marine Biology and Ecology 368 (2009) 196–201.

ash can contain toxic metals, including mercury and arsenic, which can bio-accumulate in aquatic organisms and travel up food chains; ash deposition can change the sediment characteristics and impact benthic faunal distribution[10].

An additional new problem is the plan for captive jetties or captive ports for new thermal power plants along the coast. In some cases, they are jetties which may be like offshore islands, where coal barges are expected to berth and the coal is conveyed from the jetty to the power plant through conveyor pipelines. In other cases, a port may be constructed with breakwaters and other structures. These jetties and ports as part of power plants are likely to be an additional source of problems in the littoral zone.

6.4 SEZ and other large projects

A Special Economic Zone (SEZ) is a geographical region that has economic and other laws that are more free-market-oriented than a country's typical or national laws. The category 'SEZ' covers, as well as Free Trade Zones (FTZ), Export Processing Zones (EPZ), Free Zones (FZ), industrial parks or industrial estates (IE), free ports, free economic zones, urban enterprise zones and others[11]. In order to overcome the shortcomings experienced on account of the multiplicity of controls and clearances, absence of world-class infrastructure, and an unstable fiscal regime, and with a view to attract larger foreign investments in India, the Special Economic Zones (SEZs) policy was announced in April 2000[12]. SEZs can occupy large tracts of land up to 1,000 hectares (2,500 acres) in the case of multi-product SEZs. If they are constructed on barren land as in China, they may promote the ideas with which they have been created. However, if they are set up in fertile agricultural land areas, often by forcible acquisition, it becomes a matter of great concern. The major problems caused by SEZ and other industrial projects are the result of land use change – often from fertile agricultural land to industrial layouts; displacement of the local communities; increased population densities, with areas around such developments getting converted into settlements; increase in vehicular pollution; and problems of sewage as well as industrial waste disposal. Desalination plants, pipelines to convey oil, off-shore oil and gas exploration and production are also important activities that have an impact on the littoral zone.

PHOTOS: MYTHILI D K

Figure 6.3: Desalination Plant coming up at VadaNemmeli, East Coast Road, near Chennai

Desalination plants have been touted as the best answer to the severe water shortage Indian cities face. They are constructed close to the shore, and the CRZ 2011 permits their construction in CRZ areas. In May 2012, the response to an unstarred question in parliament was that a number of cities along the coast would be getting desalination plants in the near future. The National Institute of Ocean Technology (NIOT) has

10 Herrando-Pérez, S and C.L.J. Frid, (1998). The cessation of long-term fly-ash dumping: Effects on macrobenthos and sediments. Marine Pollution Bulletin. 36(10): 780-790.

11 Special Economic Zone.http://en.wikipedia.org/wiki/special_economic_zone accessed 15 Aug. 2012 statewise number of SEZ in coastal areas.

12 Special Economic Zones in India.http://www.sezindia.nic.in/about-introduction.asp accessed 15 Aug. 2012.

indigenously designed, developed and demonstrated desalination technology for conversion of sea water into potable water based on low temperature thermal desalination (LTTD) technology. Till date, four LTTD plants have been successfully commissioned in the country, one each at Kavaratti, Minicoy and Agatti in the Lakshadweep archipelago, and one at Chennai. Tuticorin (Tamil Nadu) on the mainland, and Amini, Chetlet, Kadamath, Kalpeni, Kiltan and Androth in the Lakshadweep islands are also to get desalination plants[13]. Subsequently, Hitachi is reported to have signed an agreement with the Gujarat government to set up Asia's biggest desalination plant in Dahej Special Economic Zone (SEZ) in South Gujarat[14]. While desalination plants may help ease the potable water crisis, the setting up of the plant may have repercussions on the shoreline.

According to reports, sea water intrusion caused by the construction of the desalination plant off the East Coast Road near Chennai has claimed a stretch of coast up to half a kilometre inland in Sulerikattukuppam. There is no longer any beach there and hundreds of fishermen have lost their livelihood. They have had to join construction companies for meagre pay as they do not have any other skills. The government has built seawalls after residents protested about the erosion[15]. Hence construction of desalination plants is also a major candidate for shoreline change.

6.5 Other activities in the littoral zone

Dredging: This is basically an excavation activity that is used to deepen channels for navigation. The sediment/rock that is removed is called 'dredge spoil' and may be used for reclamation of land, replenishment of beaches, or dumped away from the site. Dredging can cause extensive disturbances in the water column, especially by increasing turbidity and suspension of bottom materials. There is also potential for local increase in wave heights due to changes in wave refraction patterns, as well as potential for beach erosion due to loss of sand sources. Two types of dredging may be recognized – capital dredging which is done initially to get the required draft in the channel, and maintenance dredging which has to be carried out on a continuous basis to maintain the draft. Dredged navigation channels also form sand traps which interrupt or disperse sediment into deeper water, disrupting the littoral drift and causing shoreline change and coastal erosion.

Sand mining: Sand is extensively used in the construction industry. It may be mined from river beds, resulting in reduction in sand quantities reaching the river mouth and promoting erosion. Mining sand also can promote saline intrusion into freshwater aquifers. Beach sand is also mined for minerals, leaving large wastelands, polluted shores and eroded beaches. Illegal beach sand mining is mainly to supply the construction industry.

6.6 Case Study 1: Diversity of Coastal Marine Ecosystems of Maharashtra: Rocky Shores at Ratnagiri & Rajapur Districts, Maharashtra[16]

The Konkan coast of Maharashtra, is now the stage for another conservation battle. This time the battle is against a slew of coal-fired power projects, nuclear power plant and mines. These developments will ravage one of Maharashtra's most serene coastal areas and portions of the Western Ghats, which are home to rich biodiversity including several globally endangered species as well as the world famous Alphonso mango. The area is also home to several rivers and rivulets which make the Western Ghat foothills productive agricultural areas. The monsoon runoff to the adjoining sea is extremely vital for sea enrichment, as the runoff not only brings water but also rich organic material from the forests. These very same organic contents help increase sea productivity, which in turn helps coastal fisheries. Not surprisingly, coastal Konkan is one of the richest fishing grounds along the Maharashtra coast.

What is of greatest concern is the scale of development:

- 15 coal-fired thermal power plants, with their own captive ports/jetties,
- shipyards,
- aquaculture farms – often in mangrove patches that are privately owned and hence can be easily converted,

13 Thoothukudi to get 2-MLD desalination plant. 7 May 2012. http://ibnlive.in.com/news/thoothukudi-to-get-2mld-desalination-plant/255475-60-118.html accessed 9 September 2012.

14 Hitachi to build Asia's biggest desalination plant in Dahej.TNN. May 23, 2012.

15 Mariappan, J. Shoreline under threat of erosion. The Times of India, Chennai. Aug 3, 2012. http://articles.timesofindia.indiatimes.com/2012-08-03/chennai/33019153_1_erosion-desalination-plant-nemmeli 5 Aug. 2012.

16 Case study contributed by Deepak Apte, Deputy Director- Conservation and Vishal Bhave, Scientist B; assisted by Vishwas Shinde and Rajendra Pawar. Bombay Natural History Society, Mumbai, India.

- mining,
- coastal tourism.

The second point is that these developments are going to happen in a narrow strip of coastal land 50 to 90 km wide and 200 km long. It becomes imperative to make a cumulative assessment of the cost and benefits of all the proposed projects, because it is evident from the impact maps provided in the report that if looked at in totality there will not be a single square kilometre left free of impact in the stretch of about 200 km of coastal Konkan from Dabhol to Sindhudurg.

The BNHS is working on a comprehensive assessment of these various projects that are likely to come up. As a first step, a baseline has to be prepared to evaluate the coastal biodiversity. This will be very helpful to document any changes that may occur due to industrial activities. Initially, a study of rocky shore coastal habitats – especially the intertidal area – of Maharashtra, has been carried out. This should enable the prioritization of sites for conservation as biodiversity hotspots. The methodology was to use a one square metre quadrant to collect data regarding overall taxonomic groups to evaluate habitat, with Opisthobranchs being used as an index to rate the habitat. Other biodiversity of the area is also being systematically evaluated.

Rocky shore ecosystems: There are three types of rocky shore ecosystems in the Konkan region. The intertidal area varies according to geographical features on land. Type I rocky shore consists of a shore with rock ledges and steep slopes and a narrow intertidal area. In type II, the intertidal area may range from a few metres to kilometres as the continental slope in such areas is very gentle and shallow. In this type are seen shallow tidal pools, loose boulders, rocks, cobbles, pebbles, etc. Type III rocky shores are a mixture of both of the above.

Opisthobranchs: Belonging to Phylum Mollusca, these are highly specialized organisms. They are habitat specialists that have specific preferences for food. Despite a narrow range of tolerance for environmental fluctuations, they are widespread. Many species are cryptic and highly seasonal in occurrence. Thus they are ideal organisms for assessing the ecological status of an area. In this study, they have been used as a single taxon to prioritize sites of conservation value. The data was generated over three seasons.

Study sites: In the first phase of the study, all the rocky shores in Ratnagiri and Rajapur districts of coastal Konkan were covered. Based on the comprehensive assessment of the Opisthobranch fauna, 10 sites have been ranked based on the species richness and diversity. Index 1 represents the sites of highest importance, whereas index value 10 represents lowest richness. These values, however, need to be looked at only in the context of the present study. Only rocky areas have been studied at these sites. It is possible that sites with lowest index for rocky shores might register a higher index for sandy shores and/or mangroves. Thus, the sites cannot be looked at in isolation.

Table 6.1: Sites and index based on this study

Site Name	Index
Mandvi (1 and 2)	1
Ambolgad	2
Undi	3
Kasheli	4
Alawa 2	5
Aare Ware	6
Alava	7
Purnagad	7
Varawade	8
Mirya	9
Madban	10

Major development projects, especially power projects, in the study area have been listed below. After that are case studies with maps that highlight the impact zone (10 km radius) of each major project on these sites. Studies on other habitats are under way.

Table 6.2: Upcoming thermal power projects in this area

	Company	Location/ Name of project	Capacity (MW)
Coal Based			
1	NTPC	Dhopave, Guhagar	1,600
2	Central Govt (NTPC)	Munge, Devgad (UMPP)	4,000
3	RGPPL	Dabhol, Guhagar	1,200
4	JSW Energy	Jaigad, Ratnagiri	3,200
5	Finolex	Ranpar, Ratnagiri	40+1,000
6	Reliance Industries	Saphale	330
7	TATA	Dehrand	2,400
8	Reliance Energy	Shahpur	4,000
9	State Govt	Uranupgradation	1,220
10	Ind Bharat Power (Konkan) Ltd .	Dhakore, Anjagaon, Sawantwadi	1,020
11	IBPKL	Sindhudurg	450
12	Ispat Energy Ltd	Dolvi (Raigad)	1,000
		Nuclear Power	
13	NPCIL	Jaitapur	10,000
		Gas Based	
14	Urban Energy Generation Pvt. Ltd	VangniTarfeTaloja, Raigad	2,100
15	M/s Reliance Industries Ltd.	Nagothane, Raigad	800
16	Urban Energy Generation	Navi Mumbai SEZ at Dronagiri , UranTaluka, Raigad	2,000
17	GMR Energy	Bhopan, Dapoli	1,980
18	Urban Energy Generation	Kondgaon, Roha, Raigad	2,100
		Captive power plant	
19	M/s Hi-Tech Carbon	Raigad	25

• Ranpar Creek to Jaigad Creek

Undi, Varawade, Bhandarpule, Aarey Ware, Mirya, Mandavi, Alawa, Purnagad are all important marine biodiversity sites which fall within this small 50 km stretch of coastal Konkan. However, this small stretch of coastal area is under severe pressure due to a few operational and a few proposed mega-projects. One very large scale aquaculture unit is also functional near Ranpar. The unit was built by cutting mangroves. Three major power projects (Finolex, JSW and NPCIL), 5 minor ports/landing jetties (Finolex, Jaigad, L& T and Bharati Shipyard at Ratnagiri and Vyate) and many coastal aquaculture farms from Jaigad creek to Ranpar creek in an approximately 50 km stretch of coastline will have significant impact on coastal biodiversity. Almost all priority sites identified during the present study fall within 10 km radius of the impact zone. It is also important to note that the present study was confined to only rocky shore habitats. The habitats such as sandy shores, sea grass beds, corals and mangroves are yet to be mapped and studied. Once the study covers all the habitats, understanding the impact of these establishments will increase tremendously.

An important factor which needs further investigation is the impact of thermal discharge (through hot water discharge from proposed thermal and nuclear projects) on the coral reefs of adjoining shores of the study sites. It is a well known fact that El Nino affected reefs through temperature anomalies (thermal stress) of 1^{o}C over a period of 2-3 weeks, resulting in coral bleaching. If the thermal stress continues for a longer duration of over 30 days, coral bleaching can result in coral mortality. This has a multitude of implications in terms of loss of biodiversity and loss of livelihood. Since thermal discharge from power plants and nuclear plants can affect sea water temperature regimes up to 6^{o}C, over longer time frames (30-80 years of plant life) the impacts on coastal

biodiversity are likely to be severe and permanent in nature. In this case of the small stretch of Konkan from Jaigad to Jaitapur (approx 100 km), there are about seven mega-power plant projects of which some are already commissioned and some under process. It is thus imperative to assess the cumulative impacts of these projects and not on a case by case basis.

Figure 6.4: Impact zone of 10km radius of each project with reference to index sites

Finolex power plant and jetty

Mandvi 1 and 2 with site index 1 comes directly under the 10 km impact radius of Finolex thermal power plant and Finolex jetty. Finolex has also proposed expansion of its plant capacity by 1,000 MW. This is definitely a cause for concern, because there are a number of sandy shores and mangrove areas within the 10 km radius impact zone. Thus the impact of the proposed activity will increase many-fold once the assessment of remaining habitats is completed

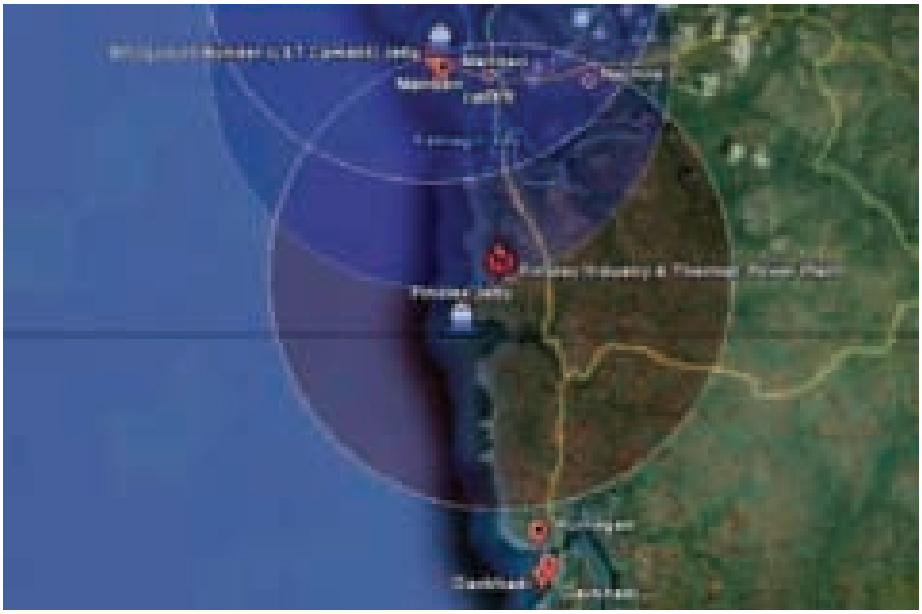


Figure 6.5: Finolex jetty, thermal power plant and impact area

Jaitapur (Madban) NPCIL nuclear power plant (proposed)

The proposed NPCIL power plant at Madban, Jaitapur (with full and final capacity of 10,000 MW) will have impact on Ambolgad (Site Index 2). Ambolgad is the 2nd best site under the present study for its species diversity and abundance. For Opisthobranchs, there are a number of new species which are yet to be described. Besides Opisthobranchs, the site is also home to inter-tidal fauna such as sea cucumbers, sea anemones, sea urchins, brittle stars, etc. The sea adjoining Ambolgad is very rich for fisheries. Musakazi is an important fishing village and jetty which is less than a kilometre from the project site. During the peak fishing season numerous trawlers use purse seines in this area. Thermal discharge from the proposed power plant will have direct influence on the fishing in this region.

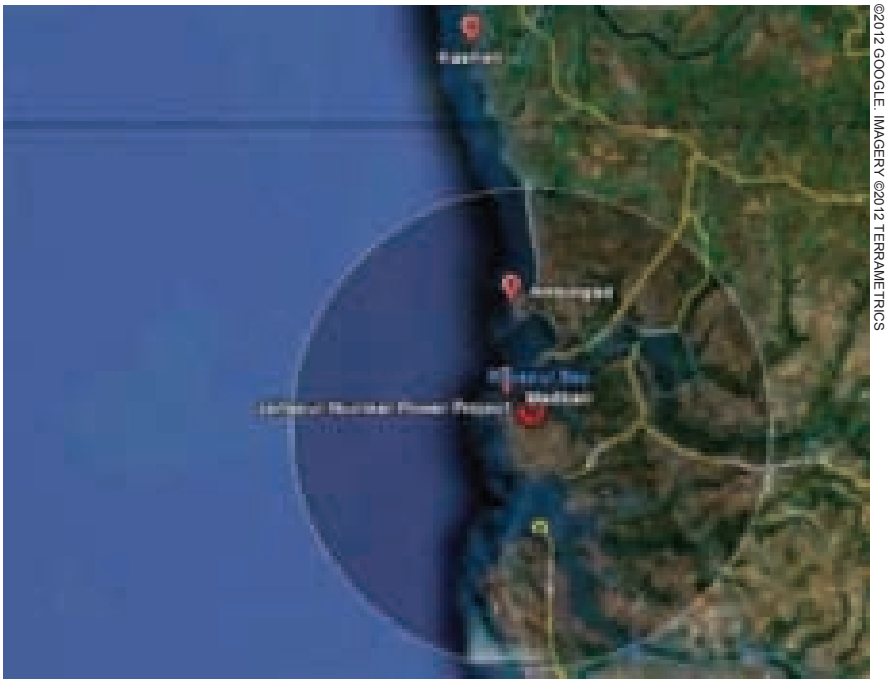


Figure 6.6: Jaitapur nuclear power plant and its impact area

Vetye Mega Shipyard by Rajapur Enterprise

The site is located between Kasheli and Ambolgadh. The development here will have direct impact on the priority sites of Ambolgad (site index 2) and Kasheli (site index 4).

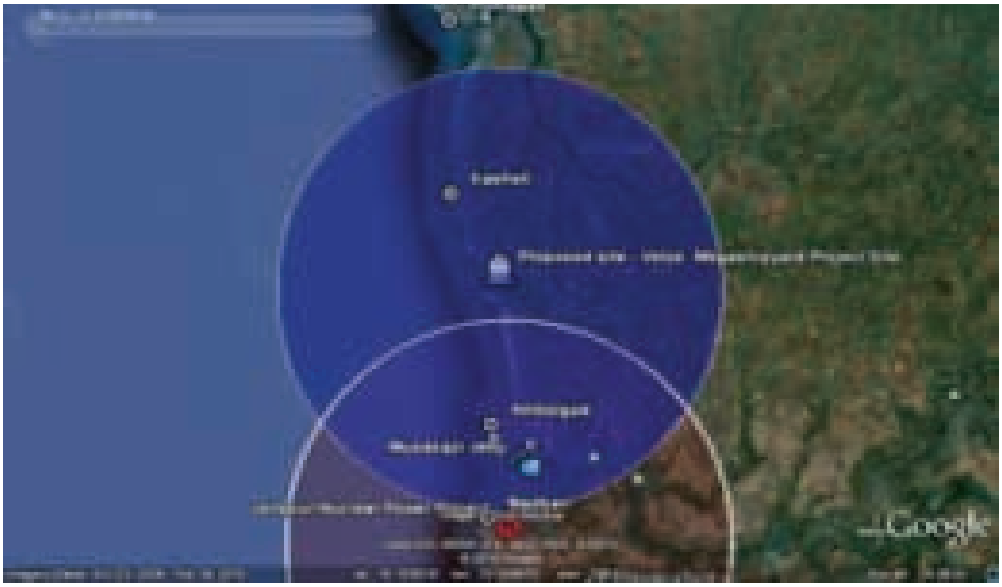


Figure 6.7: Vetye shipyard and its impact area

Sites like Ambolgad and Kasheli have immense biodiversity potential. Large congregations of marine flora and fauna are commonly seen in winter months. High densities of sea anemones are a classic example of habitat quality. These areas are under multiple impacts from various projects.

Jindal Thermal Power Plant and Jaigad Port

Jindal Thermal Power Plant and Jaigad jetty are operational now (phase 1). JSW has further expansion plans of the existing 1,200 MW power plant to the full and final capacity of 4,500 MW. Undi, the 3rd most important site (site index 3), falls within 10 km radius of the plant. Besides Undi, Varawade (site index 8) falls on the boundary of 10 km radius of the impact zone. Jaigad creek has excellent mangrove cover, which is probably among the best mangroves along the Konkan coast as well as Maharashtra State. In light of the Mumbai oil spill, preparedness of Jaigad port to combat oil spill requires assessment. Mangrove assessment of the Jaigad creek is underway: for example Kasari village has excellent mangrove cover and is within the 10 km radius impact zone of JSW power plant. There are a number of such ecologically sensitive mangrove sites which fall within the impact zone. The comprehensive assessment is underway for the same.

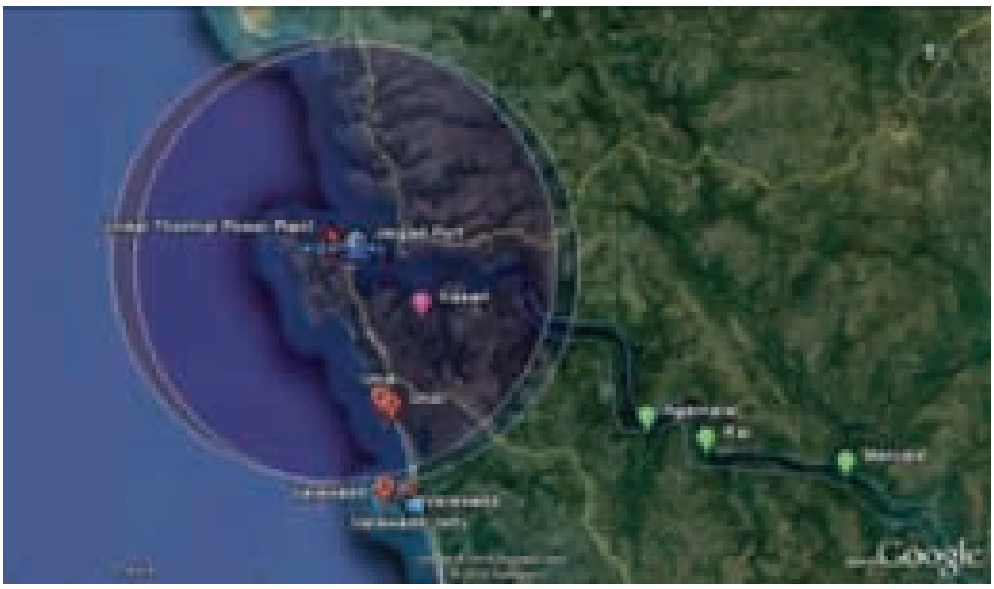


Figure 6.8: Jindal TPP, Jaigad port and their impact area

Bharati Shipyard, L & T Cement Bhagwati Bunder Jetty

Both L & T cement jetty at Bhagawati Bunder and Bharati shipyard may place severe stress on a number of index sites under study. Mirya 1 and 2 (index 1), Alawa 1 and 2 (index 7 and 5 resp) and Aarey Ware (index 6) all fall within the 10 km radius impact zone. Besides the impact of jetty and shipyard, Ratnagiri township is also in close proximity to these sites. Thus the additional impact of effluent discharge, solid waste, construction related activities, coastal development for tourist resorts, etc, also pose severe risk of stress to these sites.

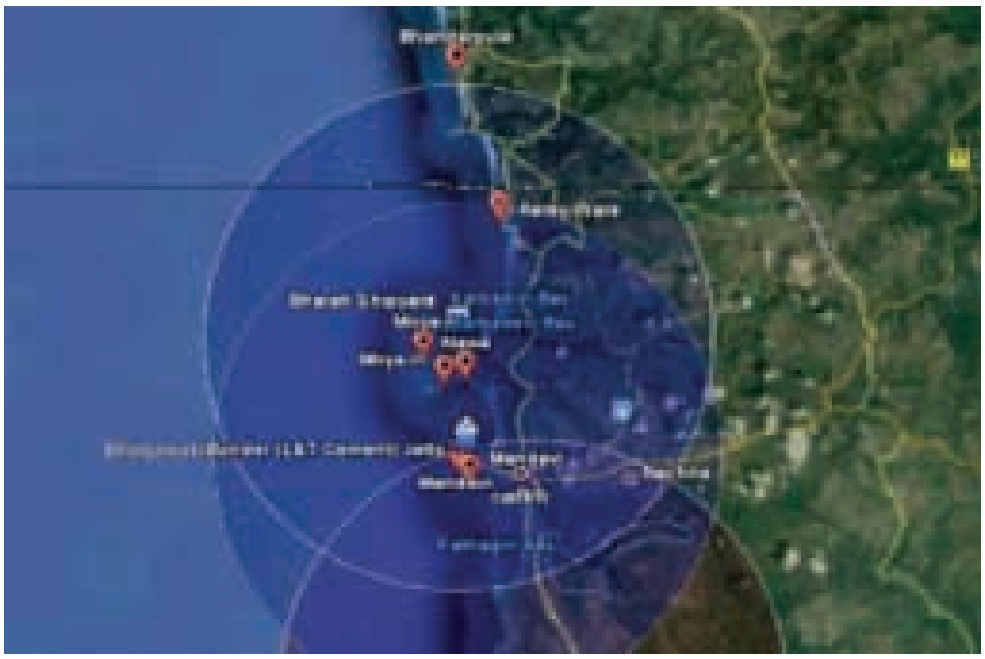


Figure 6.9: Impact areas of Bharati Shipyard, L & T Cement Bhagwati Bunder jetty

6.7 Case study 2: Mundra[17]

BACKGROUND AND CONTEXT

Ecological importance: Mundra is a coastal taluka located on the northern bank of the Gulf of Kachchh in Gujarat. The Gulf of Kachchh is especially interesting in bio-geographical terms. To the north, the fauna is influenced by the Arabian Sea upwelling regime and there appears to be a dramatic faunal change from northern India across Makran and into the Arabian Gulf. The Indus fan is a large hydrographic influence, but we know little about its function to create a faunistic barrier or what special environment it creates. Thus the fauna of Gulf of Kachchh has some species so distinctly distributed that these are present nowhere else along the Indian coast-line e.g. *Lunella coronata*, *Monodonta australis*. The faunistic barrier created in the case of *Lunella coronata* has been well studied by Williams & Apte et al (2010)[18]. In 1982, parts of the Gulf of Kachchh were declared a Sanctuary and Marine National Park. The Gulf of Kachchh is the only place left on the Indian coast, after the Gulf of Mannar, where there is occurrence of live corals. The Kachchh district is also declared as the most important mangrove area in the state of Gujarat, and the Mundra region is known to have almost 2,096 hectares of mangroves. The significance of mangroves is not debatable: the Government of India and the Ministry of Environment and Forests recognize that mangrove forests are ecologically sensitive areas and need to be protected and conserved. Mangroves are critical to coastal soil conservation, as breeding and nursery grounds for fish, crustaceans and other sea life, as well as vital habitat for birds and other wildlife. The Gulf also abounds in algal species. Thus the Mundra coast in the Gulf of Kachchh is an eco-sensitive area which provides a supportive ecosystem for a large variety of flora and fauna.[19]

17 Based on work, data and inputs from Bharat Patel, Machimar Adhikar Sangharsh Samiti (MASS), and Kanchi Kohli compiled by TISS team with July 2012 field notes input from Adya Shankar, Aravind Sreedhara, Balamurugan Guru and Sudarshan Rodriguez, TISS.

18 Williams, Suzanne, D.A. Apte, Ozawa Tomowo, Kaligis Fontje, Nakano Tomoyuki (2010). Speciation and dispersal along continental coastlines and island arcs in the Indo-West Pacific turbinid gastropod genus Lunella. Evolution, 65-6: 1752–1771.

19 Fishmarc and Kutch Nav Nirman Abhiyan, 2010. “Kutch Coast – People, Environment & Livelihoods”.

Source: Bharat Patel, MASS

Figure 6.10: Mundra, Gulf of Kachchh

Coastal communities: The Kachchh region has a significant rural population, most of whom live and earn their livelihoods near the coast. Coastal resources provide abundant local economic opportunities. The Mundra region has one of the highest rural population densities. The region provides an environment for several sea-based traditional occupations like fishing and salt-making along with land-based occupations like agriculture, horticulture and animal husbandry[20]. The Kachchh coastline houses around 3,500 fishing communities, and the 72-km long coastline of Mundra houses nearly 10 fishing settlements. The Wagher fishing communities are known to have been involved in fishing for almost 200 years. They follow a transient and self-sufficient settlement pattern, where the entire community lives in the Bandar for 8-10 months a year, and during the remaining months moves to the mainland, while continuing to practice Pagadiya fishing. A large number of allied activities associated with fishing, including vending, processing, net-making and repairing, etc, make fishing a Rs.100 crore economy in Mundra. Livestock rearing is a significant economic activity for the Maldari, Rabari and Ghatvi communities, who use large tracts of land notified as Gaucher land[21]. Mundra produces one-tenth of the salt produced in the Kachchh region, with almost 15,000 persons employed in salt-making activities. Western Mundra region is a horticulture belt known for its Chickoo and Date Palm plantations. Many communities are involved in mixed farming, practicing agriculture along with horticulture and animal husbandry.

Source: Bharat Patel, MASS

Figure 6.11: Juna Bandar, Mundra

20 Ibid

21 Perspectives Group, 2012. “Swimming against the Tide - Coastal Communities and Corporate Plunder in Kutch”, Economic & Political Weekly, Vol - XLVII No. 29.

Mundra water-front development: Over the last 15 years the Mundra region has been experiencing intense industrialization and infrastructure building through port expansion and thermal power installations, and has become a hub of refineries and multi-product SEZs. Media reports have highlighted that the four top business houses have invested about $34 billion along the Gulf of Kachchh's 700-km-long coastline[22]. The largest-capacity ultra-mega-power plant in the country and a massive multi-product port-based SEZ in the Mundra region of Kachchh district are changing the face of the northern coast of the Gulf of Kachchh. All this was eventually to form part of the grand Mundra SEZ plan, to be spread over 10,000 hectares covering 14 villages, with an investment of Rs. 73,000 crores, which was approved at the state level in 2003-04, and in April 2006 by the Ministry of Commerce at the Centre[23]. The 2004 state approvals were followed by the second phase of intensive destruction of mangroves in the Bocha, Abhanvadi and Gujarat Maritime Board areas (near the old port) in 2005[24]. Termed 'Water-front development', the path of industrial development is drastically changing the natural coastal ecosystems and associated livelihoods, making Mundra a highly complex case in point of uncontrolled coastal destruction. The following sections highlight the range of issues and impacts of development in Mundra.

Source: Bharat Patel, MASS

Figure 6.12: Proposed development in MPSEZL

Violations and destructions all the way

Mundra was a region which housed more than 20% of the mangroves of the Gulf of Kachchh, until eight years ago. It has a five-kilometre wide intertidal zone housing these mangrove forests. The process of deforestation and clearing started in 1998 using methods such as direct felling, bunding and starving off of sea water (leading to drying up of the mangroves), and excavation and filling of the area with sand dredged from the creeks and channels close by[25]. Port and SEZ construction activities have also resulted in the blocking or diversion of creeks

22 Asher, Mansi. "How Mundra became India's Rotterdam." InfoChange News and Features, December 2008.
23 Kaur, R. 2010, Mundra SEZ skirts rules, Down to Earth, November 15.
24 Asher, Mansi. "How Mundra became India's Rotterdam." InfoChange News and Features, December 2008.
25 Asher 2008

and rivers. An official team from MoEF found that Adani were blocking the natural flow of water into the creeks and as a result choking surrounding mangrove forests.[26]

Salt pans as means of backdoor entry*:* In the case of salt pans, land allocated for salt-making has been diverted to construct industries. It is alleged that industries manipulatively acquire forest lands under the pretext of salt pan development, and then divert the land-use to SEZ development[27] (salt pans are legally allowed under CRZ 1991 and 2011). Figure 6.13 shows a recent development at Tuna port[28], where a 3.7 km road is being constructed by Adani, protruding right into the sea, on mangrove land, blocking nearly three creeks, for the purpose of building a satellite port under the Kandla Port Trust.

Figure 6.13: Road construction under way for proposed satellite port at Tuna[29]

Figure 6.14: Mangroves on side of road termed in EIA report as "the mangroves are therefore scattered and not healthy"[30]

Strangely, the clearance[31] for this project does not mention "not blocking creeks and rivers in mangrove areas" in the clearance. It also terms the mangroves as "scattered and not healthy" and attributes it to the high salinity due to evaporation. However, first the mangroves are not scattered and unhealthy, and secondly their health would be better if the area were not leased out for salt pans (part of the land does belong to Kandla port, which has been under the scanner for leasing almost 16,000 acres to salt pans without auctions[32]). How much of this land earlier had mangroves is not known, but from the image below it does seem that salt pans were built over mangrove areas. There have been studies and reports implicating Kandla port for destruction of mangroves[33].

Figure 6.15: Google image prior to construction of road[34]

26 Yadav 2011.

27 Asher 2008.

28 Anon 2012, Adani, KPT to join hands for satellite port in Tuna, Times of India http://articles.timesofindia.indiatimes.com/2012-01-03/rajkot/30584271_1_kpt-kandla-port-trust-satellite-port From TISS CAMP Field Survey 7th July 2012.

29 From TISS CAMP Field Survey 7 July 2012.

30 MoEF 2011, Minutes of the 105th Meeting of the Expert Appraisal Committee for Building/ Construction Projects/ Township and Area Development Projects, Coastal Regulation Zone, Infrastructure Development and Miscellaneous Projects held on 21st and 23rd September 2011.

31 Ibid.

32 Bawja, H. 2011, Gujarat: Land scam worth Rs. 2 lakh crore exposed at Kandla Port, India Today, June 29, 2011 http://indiatoday.intoday.in/story/gujarat-land-scam-exposed-at-kandla-port/1/143100.html.

33 Shah, R. 2006, Ports destroying state's mangrove cover: Study, Times of India, http://articles.timesofindia.indiatimes.com/2006-07-09/ahmedabad/27800106_1_mangrove-sq-km-oil-spills; Singh, H.S. Mangroves and their environment: With Emphasis on Mangroves in Gujarat, Gujarat Forest Department.

34 From TISS CAMP Field Survey 7 July 2012.

Extending salt pans beyond HTL- creation of new land and HTL: In a bizarre situation, there has been expansion and creation of salt pans beyond HTL (between HTL and LTL).

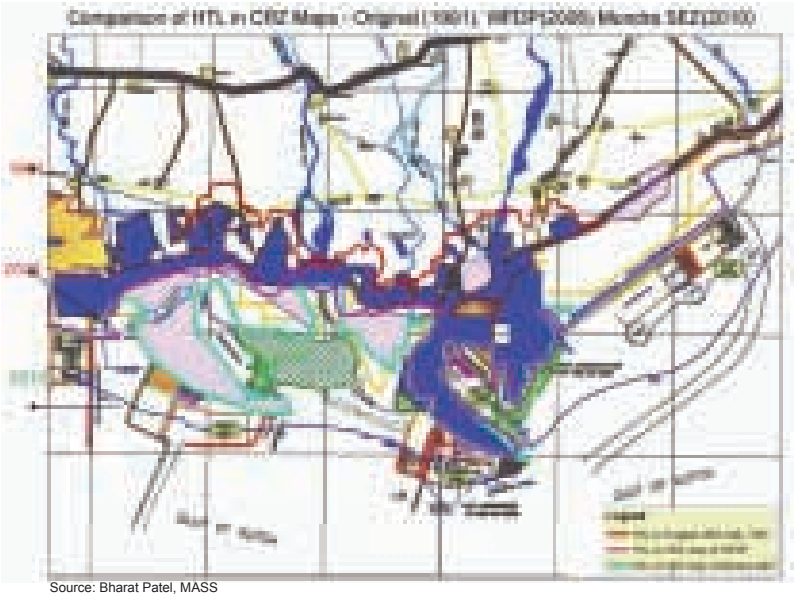
Figure 6.16: Image of 2012

Figure 6.17: Image of the above location in 2005

Shifting HTL in CRZ maps: Existing and proposed industrial development in Mundra showcases a string of violations of Coastal Regulation Zone (CRZ) norms. According to the government maps of 1996 the proposed Mundra SEZ falls within CRZ-I zone, so thereby most construction activities could be considered illegal. However, the maps submitted by the Adanis for clearance of the Water Front Development Project in 2008 marked the High Tide Line (HTL) 3 km south of what is shown in the state maps from 1991. Maps submitted in 2009 for

clearance of the SEZ further shifted the HTL again by 7 km. Adani's have built a large township, hospital, and even an airport close to the coast. According to Machimar Adhikar Sangharsh Samiti (MASS), evidential imagery obtained from the Indian Remote Sensing Satellite 1D has shown that the reclamation of land, blocking of creeks, destruction of mangroves, and the commencement of port construction in Mundra has actually happened prior to obtaining environmental clearance clearance.[35]

Factually incorrect and misleading EIA: Studies have shown the shoddy process of environmental clearance and impact assessments for various projects in Mundra. EIA reports reflect the minimal groundwork done by the appointed consultants. Many reports falsely portray the project area as barren or waste land, thus suggesting insignificant environmental impacts due to development activities. The EIA reports also falsely reflect that project areas have no habitation and thus would not need any resettlement and rehabilitation measures. For most projects, there were no public hearings conducted, and whenever they were conducted they were a mere formality conducted without adequate recognition of project-affected communities[36].



Source: Bharat Patel, MASS

Figure 6.18: The shifting HTL between 1991, 2008, 2010[37]

A review of social and environmental impacts

Shoreline changes: There have been shoreline changes in the form of erosion that have had serious implication on livelihoods and settlements as well as mangrove cover and mudflats. The reasons for the same could be many-fold – land-use change, mangrove destruction, blockage of creeks, damming of rivers etc. The satellite images below illustrate this.

Figure 6.19: Randh Bandar 2005

35 Perspectives Group, 2012. "Swimming against the Tide - Coastal Communities and Corporate Plunder in Kutch", Economic & Political Weekly, Vol - XLVII No. 29.

36 Independent Fact-Finding Team, 2012. "Real Cost of Power", Report of The Independent Fact-Finding Team on The Social, Environmental, and Economic Impacts of Tata Mundra Ultra Mega Power Project, Kutch, Gujarat.

37 Fishmarc and Kutch Nav Nirman Abhiyan, 2010. "Kutch Coast – People, Environment & Livelihoods".

Figure 6.20: Randh Bandar 2012 (red line is approx shoreline in 2005)

Mangroves: In the ecologically sensitive CRZ-I zones of Mundra, over 1,000 hectares of mangrove forests have been destroyed since 2005[38]. These have had a direct impact on local environmental conditions and communities. Mangroves act as breeding grounds for fish and also provide fuel and fodder to the locals. Illegal cutting of mangroves has led to salinity ingress in the Mundra region. There is also a perceived increased vulnerability to future disasters such as cyclones.[39]

Livelihoods: Industrial development along the coastline of Mundra has created multiple impacts on fisher communities. Many industries have come up on/near the bandars, leading to displacement of these communities or cutting of their normal access routes to the bandars. People attribute the industrial pollution, especially the thermal pollution from the power plants located on the coast, to decline in their fish catch[40]. A recent fact-finding study conducted on the Tata Power CGPL plant in Mundra found high sea water temperatures at the outfall channel created for the plant[41]. Furthermore, the blocking of creeks and estuaries in the region has decreased the areas traditionally used by fisherfolk for fishing activities.

Lack of access to common land is not limited to only the fishing communities. Large tracts of grazing land have also been illegally encroached upon by the industries. As per Gujarat Government norms, Mundra, having an average of 2,000 cattle, should have nearly 2,500 hectares of grazing land for sustainable animal husbandry[42]. Large tracts of gaucher land have now been given away to industries. As a result there has been a drastic reduction in livestock, thereby negatively impacting the livelihoods of the grazing communities.

The fact-finding study[43] on the Tata CGPL also indicated the impacts of air pollution from the Mundra and Tata power plants particularly affecting different communities in the vicinity. The plant has a long conveyor belt to transport coal from the nearby Mundra port. Fly ash from this project has increased air pollution levels drastically, which has led to multiple impacts such as contamination of dry fish and salt in the salt pans, fruition time of date palms, reduction in coconut plantation, and overall health hazards to villagers. Salinity ingress along the horticulture belt, on the west coast of Mundra, has also led to a fall in Chickoo plantation.

38 Yadav, A. 2011, Vibrant Gujarat? Your coast is not clear, Mr Adani, Tehelka Magazine, Vol 8, Issue 8, Dated 26 Feb 2011. http://www.tehelka.com/story_main48.asp?filename=Ne260211DEVELOPMENT_CONFLICTS.asp

39 The 1998 cyclone in Kutch did not adversely affect the Mundra coast.

40 Independent Fact-Finding Team, 2012. “Real Cost of Power”, Report of The Independent Fact-Finding Team on The Social, Environmental, and Economic Impacts of Tata Mundra Ultra Mega Power Project, Kutch, Gujarat.

41 Ibid.

42 Fishmarc and Kutch Nav Nirman Abhiyan, 2010. “Kutch Coast – People, Environment & Livelihoods”.

43 Independent Fact-Finding Team, 2012.

Conclusions

The Mundra coast is very critical for fisheries production, agriculture, livestock, salt manufacture and horticulture. Most of these activities are undertaken by artisanal fishers, small scale salt producers and farmers. Unfortunately, little attention is being paid to the unprecedented environmental and social fall-outs of this makeover. While processes for prior environmental clearance are required, they are for individual units and do not factor-in regional or cumulative aspects. The conflicts over large scale land acquisition by corporate groups, land use change and environmental impacts caused by industrial development are open and have led to several court cases and ground level mobilizations against these projects.

The Machhimar Adhikar Sangharsh Sangathan (MASS) is an active NGO which has been working in the Mundra region on community mobilisation and capacity building of the traditional fishing communities of Kachchh. It is a part of the broader 'Setu' programme of Kachchh Nav Nirman Abhiyan. MASS has been part of state level and national level campaigns organized or supported by the National Fishworkers' Forum (NFF). This movement has been instrumental in mobilizing not just the fisher communities but also other communities in Mundra who are facing the threats and impacts of industrialization in Mundra.

A number of development and environment professionals as well as orders on court cases have suggested that a Cumulative Impact Assessment of the coast be done so that decisions on siting of new plants and land use as well as monitoring of existing facilities can be done better.

6.8 Case Study 3: Shoreline change caused by ports and harbours

Background: The manner in which coastal structures have an impact on the natural stability of the shoreline was described In Chapter 5. How coastal structures can cause either erosion or accretion of the coast, thereby changing the original profile, alignment and nature of the shoreline, was described in detail in section 5.6 of that chapter. The shoreline change that was described in the case study was predominantly caused by coastal structures – breakwaters, seawalls, groynes, etc – that either belonged to or were related to the minor port and relatively small fishing-cum-commercial harbour of Puducherry.

Similarly, the numerous ports and harbours, minor and major, small and large, for fishing and commercial activities, about 143 of them in all, that were found to be located within the littoral zone, dotting the Indian coastline, all have structures that have an impact on the profile and alignment of the shoreline. Such an impact caused by ports and harbours can be more or less significant depending on the type of coastal environment and processes that are present in a given locality, and equally on the kind of structures that have been erected as well as the activities that are being undertaken there. Numerous examples of shoreline change caused by ports and harbours, at several locations along the Indian coast, have been documented. The most salient examples are presented here as typical case studies.

Shoreline change observations due to construction of ports and harbours:

The information on case studies that are compiled and presented here below have been studied and published by several scientists and government institutions.

East Coast:

Chennai port, Tamil Nadu

Chennai port was first built in 1861 as a single pier of 335 m and was only much later developed as a full-fledged port when the outer harbour was commissioned in the year 1972. Prior to the development of Chennai harbour the Chennai coastline was in dynamic equilibrium. The harbour structures have resulted in changes in the coastal dynamics along the coast to the north, because of which 11 km length of the coast extending from the fishing harbour to Ennore creek is under enormous stress. The coast north of the harbour has been experiencing erosion at the rate of about 8 metres per year since the Chennai harbour was constructed. It is estimated that 500 metres of beach width has been lost between 1876 and 1975, and another 200 metres between 1978 and 1995. The shoreline has receded by about 1 kilometre with respect to the original shoreline of 1876 [44]. (Fig.6.21)

44 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

It is estimated that about 260 ha of coastal land had eroded between 1893 and 1955, and an area of ca. 30 ha was additionally lost between 1980 and 1989[45]. The overall loss between 1893 and 1989 is estimated to be ca. 350 ha[46]. This means that on average the north Chennai coastline has lost about 3.5 to 4 ha of coastal land per year since construction of the Chennai port. The cost of land alone lost to the sea, valued in the year 2001, has been estimated to be worth 40 million US$[47].

The layout of Chennai port and its effect on the adjacent shoreline is shown in (Fig. 6.21) which shows the present day configuration of the port and the shoreline change on either side of the harbour that has taken place over the years. Toward the south of the harbour, the Marina Beach has been formed as a result of arresting the littoral drift by breakwater, whereas to the north the Chennai coast extending from the fisheries harbour is fragile, and is very sensitive to change. The main reason for the fragility of this coastal stretch is the disruption in sediment supply induced by the Chennai port, which has been causing extensive erosion over the years.

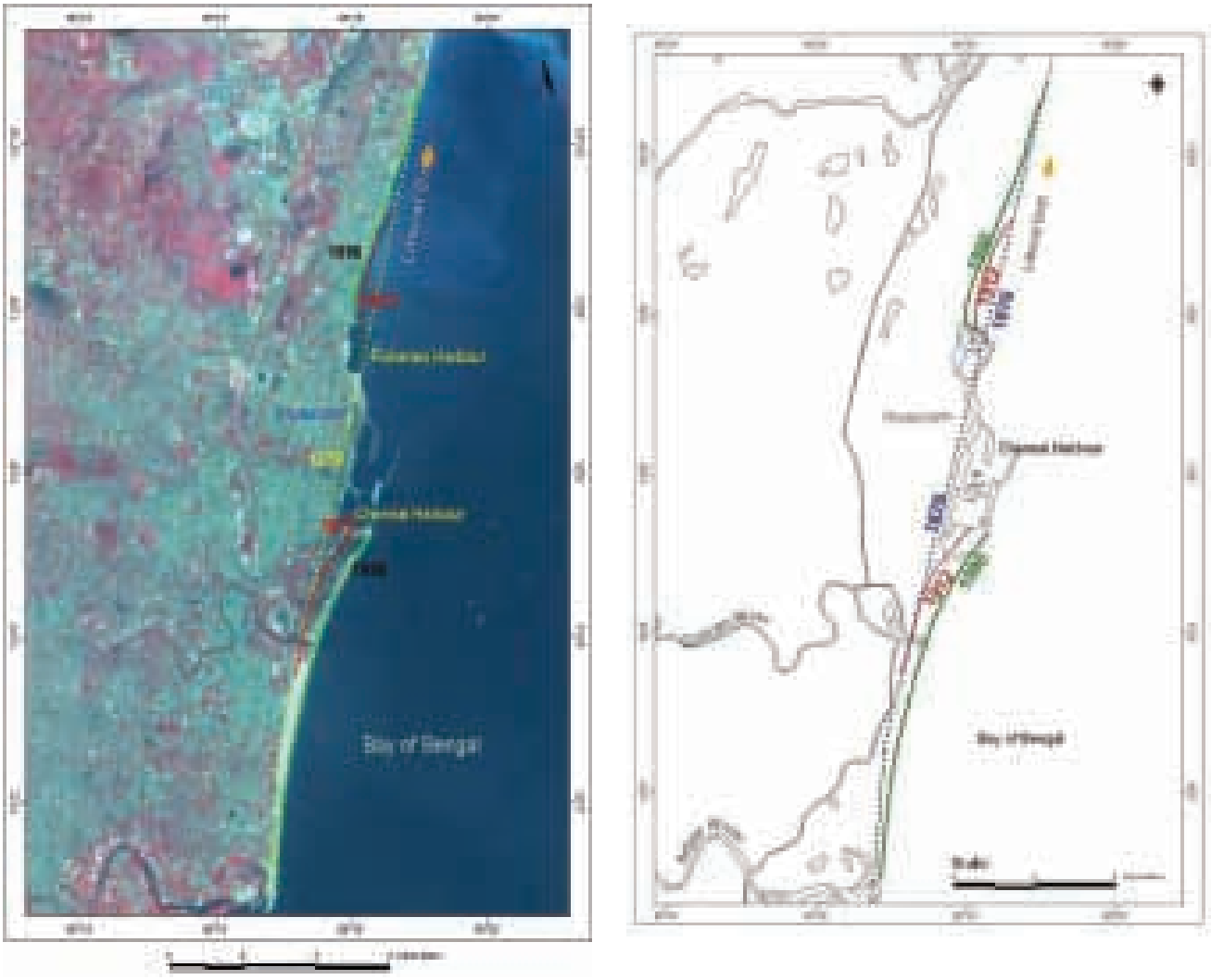


Figure 6.21: Configuration of Chennai port and shoreline changes. (Source: MoES).

45 Mani, J.S. 2001. A coastal conservation programme for the Chennai seashore, India – a case study. Journal of Coastal Conservation, 7, 23-30. 2001.

46 Ibid.

47 Ibid.

In order to protect the coastline, the State authorities resorted to construction of short-term protective structures i.e. rubble mound stone wall and groynes. These protected coastal stretches experience undermining of the seabed due to large-scale wave action. Though the short-term measures taken up by authorities gave temporary relief to the villages in protected areas, the problem is not resolved completely. Due to construction of the stone wall (Fig. 6.22), the natural beach available was lost and the downdrift villages north of protected areas started experiencing erosion.

Figure 6.22: Sea wall along Rayapuram. (Source: MoES[48]).

Ennore port, Tamil Nadu

Ennore port is located 17 km north of Chennai port, between two tidal inlets viz., Pulicat to the north and Ennore creek to the south. The coast has distinct morphological characteristics such as narrow barrier spit, shoals and a coastal orientation, all of which form a complex near-shore system. The port was constructed in the year 2000 and became operational in 2001. It has a water-spread area of 240 ha with a south-eastern entrance, sheltered by breakwaters that are 1.1 km long on the south and 3.2 km long on the north (Fig. 6.23).

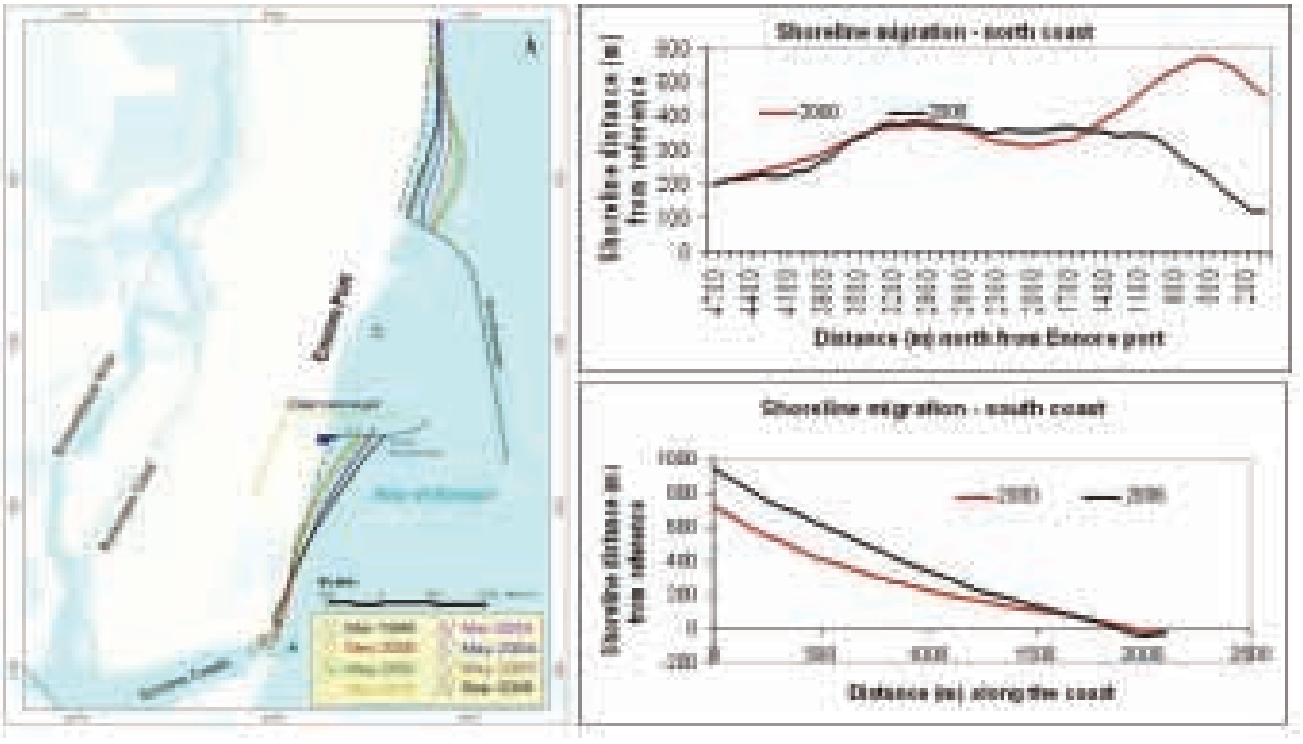


Figure 6.23: Observed shoreline at Ennore port (1999 to 2006). (Source: MoES[49]).

The construction of the Ennore port breakwaters has arrested the movement of longshore sediment transport, resulting in accretion on the south side and erosion on the north side. As erosion was expected on the north side, to prevent downdrift erosion the port authorities had artificially nourished the northern

48 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

49 Ibid.

part of the shoreline at the time of port construction in the year 2000, by placing there 3.5x106 m3 of sand dredged from the harbour basin and the approach channel through capital dredging. The shoreline around the Ennore port was regularly monitored from 1999 to 2006 in order to understand the impact of the port on the coastline[50].

The study revealed that as the sediment moves south to north, and the breakwaters stop the free movement of sediment along the coast, severe erosion took place in a 1.5 km stretch of coast to the north of Ennore port, with an erosion rate of 50 m/year. The beach-fill carried out in the year 2002 as anti-erosion work lasted till the year 2007. Further to the north, the impact of coastal erosion caused by the breakwaters was seen up to Kattupalli village, 3 km north from the port, where the shoreline underwent readjustment over the period with moderate erosion of 50 m. The shore south of Ennore port has accreted at a rate of 45 m per annum, extending offshore 300 m to 400 m (during 2000-2006). The zone of accretion extended south up to 2.6 km along the shore, where a 90 m wide beach has developed that eventually lead to rapid silting of Ennore Creek, from where cooling water is drawn by the Ennore power plants. It was also found that the inlet of Pulicat Lake was shifting due to the shoreline change[51]. The long-term analysis of wave climate and coastal profile has revealed that if no intervention is planned the northern areas of the port will suffer erosion at the rate of 20 m per year.

Shoreline change around Bhavanapadu harbour, Andhra Pradesh

Bhavanapadu fishing harbour was constructed during 1983-88, with breakwater structures on the northern and southern side of the mouth of the creek, (Fig. 6.24) at the confluence of the Tekkali Creek in the Srikakulam district of North Andhra Pradesh.

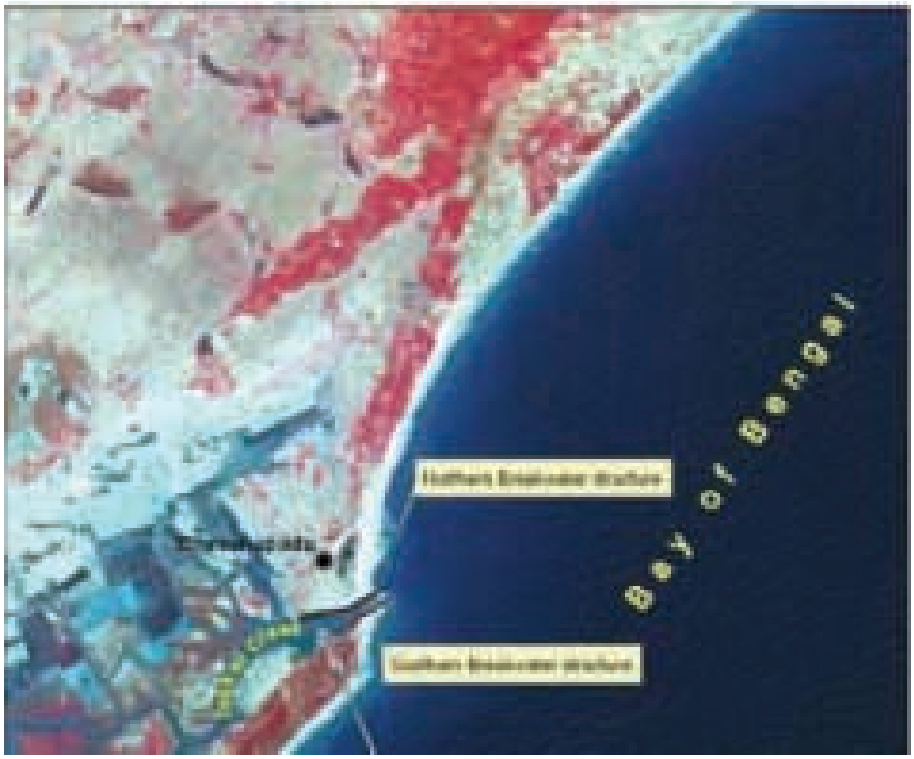


Figure 6.24: Study area for coastal processes: Bhavanapadu. (Source: MoES[52]).

50 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

51 P. Kasinatha Pandian, S. Ramesh, M. V Ramana Murthy, S. Ramachandrana, and S. Thayumanavan.2004. Shoreline Changes and Near Shore Processes Along Ennore Coast, East Coast of South India. Journal of Coastal Research: Volume 20, Issue 3: 828-845.

52 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

The 32-year analysis of the Bhavanapadu shoreline shows that it is primarily dominated by erosion. The shoreline on either side of the mouth of the creek was in the process of erosion before construction of the breakwaters. However, the construction of breakwaters accelerated the rate of erosion, starting from a distance of 1.3 km north of the northern breakwater[53].

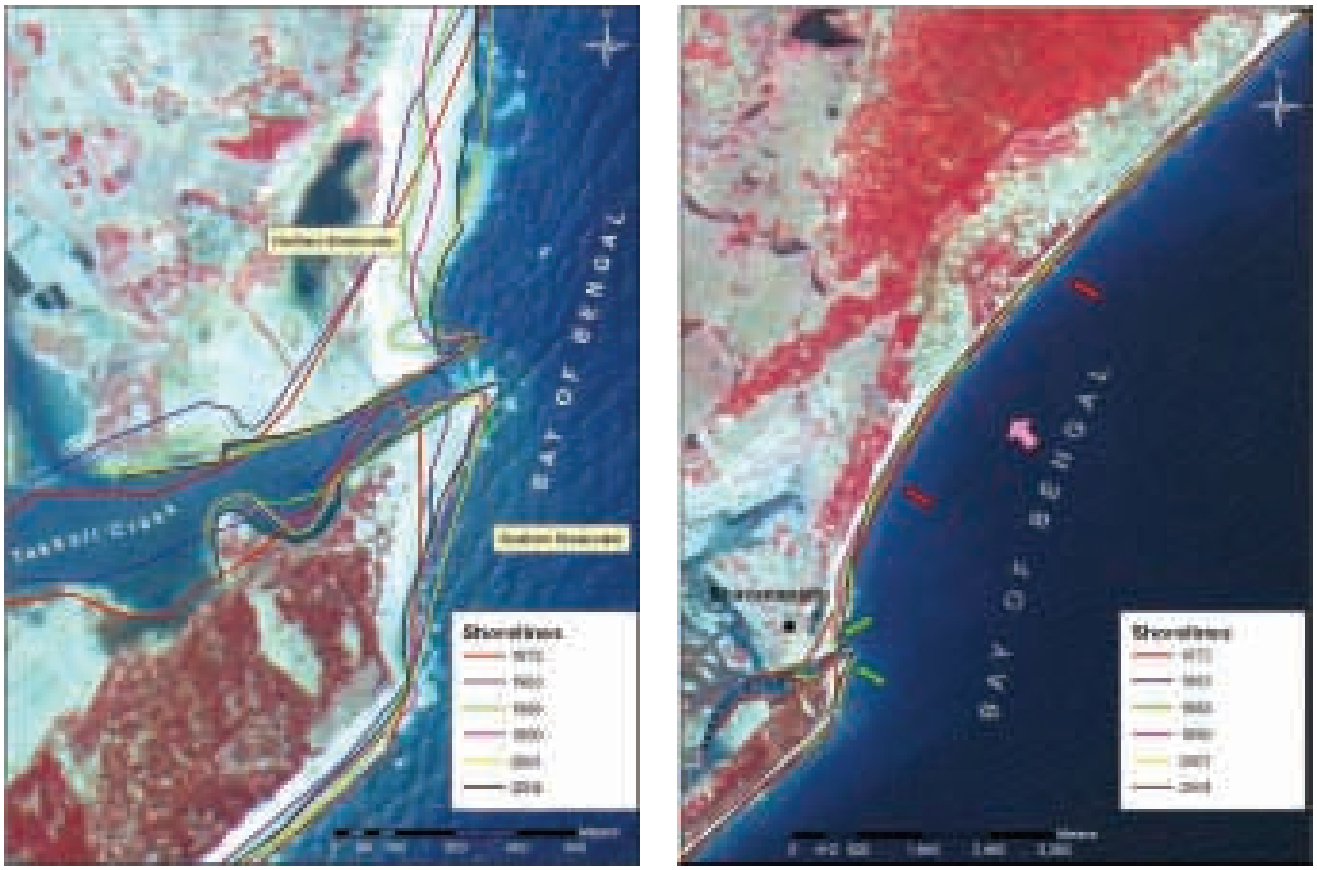


Figure 6.25: Erosion and accretion zones around Bhavanpadu and change in shoreline around inlet. (Source: MoES[54]).

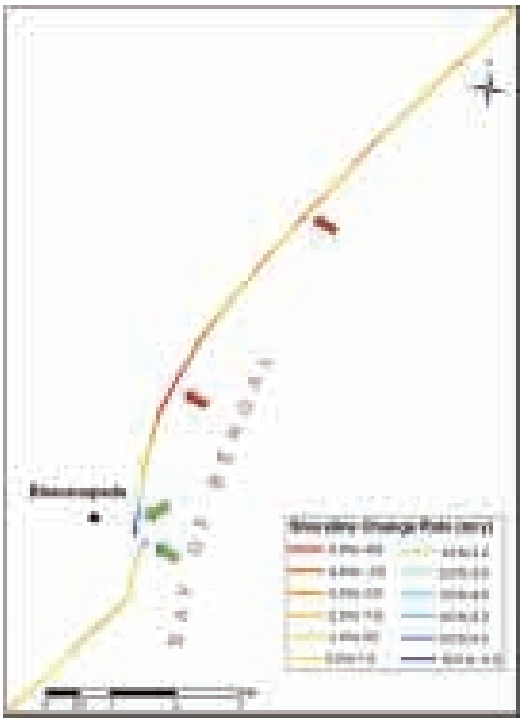
Maximum erosion was observed in two stretches along the shoreline to the north of the creek, shown by red arrows in (Fig. 6.25), with shoreline changes taking place around the inlet.

The only areas of considerable deposition in the study area are observed in and very near the creek mouth, as well as in the channel. Shoreline-change rates for 1972-2004 indicated that most of the area has experienced erosion, which can be clearly seen in (Fig. 6.25). The maximum erosion rate is up to 4.7 m per year, which is observed in the northern part, and the maximum accretion rate up to 10.4 m per year, which is observed on the seaward side of both the walls. Further, the deposition of sediment was observed also in the navigation channel as seen from the satellite data of 2004[55].

53 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

54 Ibid.

55 Ibid.



Construction of the breakwater has considerably altered the sediment budget within the study area. While accelerating erosion on the northern part of the creek mouth, it has accelerated deposition at the creek mouth. The construction of breakwaters has altered the sediment supply from the south, with much of the sediment getting deposited near the mouth and less of it being able to move northwards. This was aggravated by the reduction in sediment supply from within the creek due to development of saltpans and aquaculture activity in the catchment.

Figure 6.26: Shoreline Change Rate (+ve accretion and –ve erosion, red/green arrows indicate areas of severe erosion/accretion). (Source: MoES[56]).

Krishnapatnam port (Nellore), Andhra Pradesh

Krishnapatnam port is located in Kandaleru creek in Nellore district of Andhra Pradesh. The shoreline changes around the port were studied for one year during the period June 2007 to May 2008[57]. Results showed that there was slight erosion in the northern parts of up to 2 km. Beyond that point there was slight accretion, and more or less no change in the southern parts observed.

The shoreline change rates that were determined indicate that the severely eroding areas shown with red arrows in (Fig. 6.27) had erosion rates of about 30-35 m/year. The net shoreline change that was calculated for the study area depicts the erosion in the northern and southern parts.

Figure 6.27: Shoreline Change Rate (+ve accretion and –ve erosion, red/green arrows indicate areas of severe erosion/accretion). (Source: MoES[58]).

56 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

57 Ibid.

58 Ibid.

Visakhapatnam port, Andhra Pradesh

The shoreline near Visakhapatnam port is marked by the presence of a rocky headland with narrow beaches (Fig. 6.28)[59]. The behaviour of the coast around the port area was already being very carefully monitored even when only the inner harbour of Visakhapatnam was developed. The creation of the navigation channel for the inner harbour by intercepting sand in the sand trap, providing protection against waves by using sunken ships, and bypassing sand with the use of dredgers and floating pipeline, was already being adopted even in the 1960s, when the outer harbour development was still being taken up. As the length of the breakwaters of the outer harbour was more than 1.5 km, most of the littoral drift was getting blocked by the breakwaters. Studies of the geomorphological aspects of the coast, like littoral drift, provision of sand trap and sand bypassing, were taken up prior to the project and helped in identifying the exact need of bypassing/beach nourishment on the northern beach.

The beach nourishment has been optimized after extensive studies were conducted at CWPRS. The need for bypassing at least 0.3 million cubic metres of sand yearly on the northern beach has been determined. With more and more bypassing, wider sandy beaches can be assured to the north. The case of Visakhapatnam port shows how prior studies, judicious and careful planning of dredging operations, and continuous monitoring, can help in stabilizing adjacent coastline in an effective manner despite the large littoral drift in the region[60].

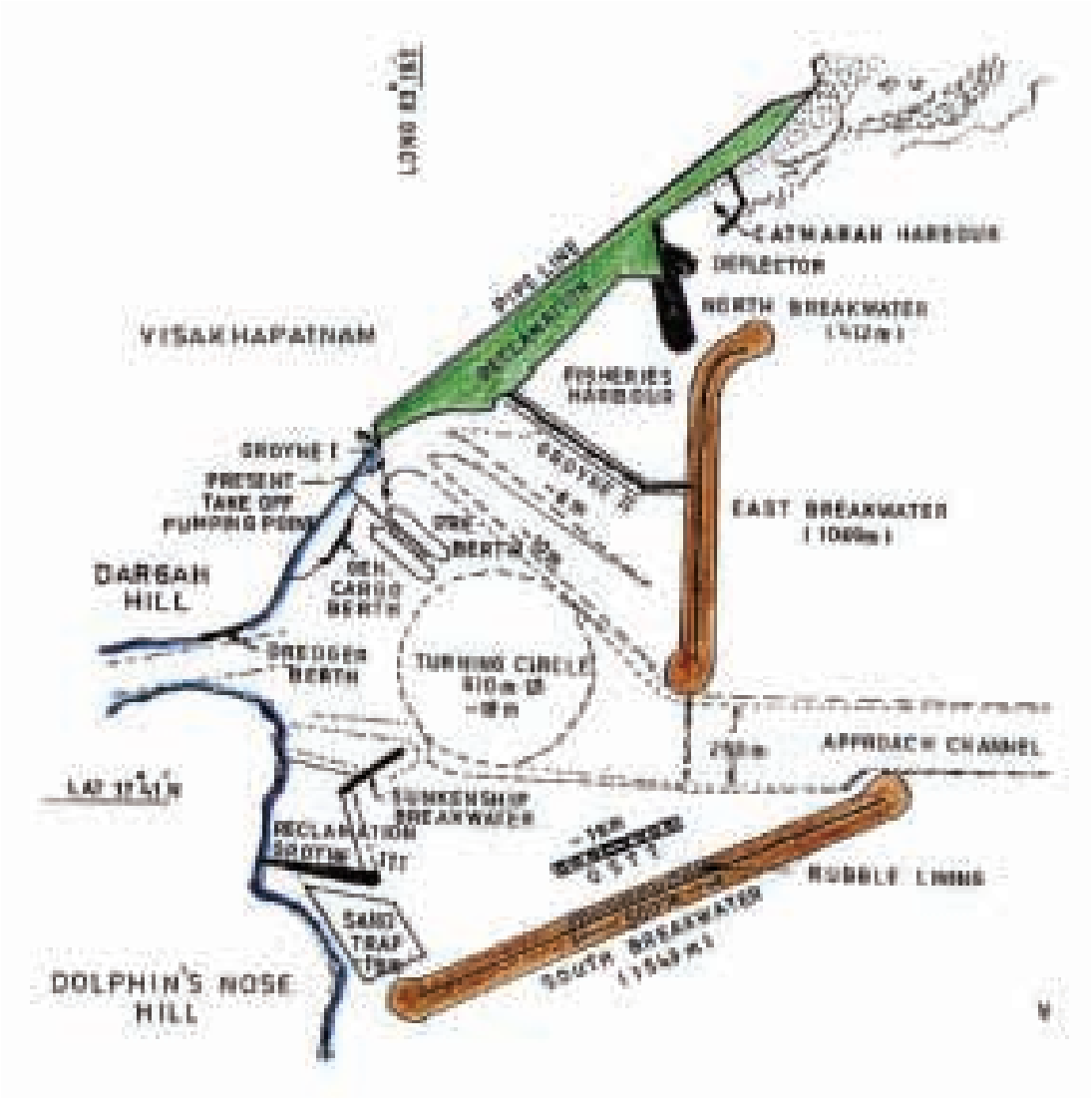


Fig. 6.28: Layout of Visakhapatnam port showing breakwaters and sand Trap. (Source: Kudale, M.D.[61]).

59 Kudale, M.D., Impact of port development on the coastline and the need for protection - Indian Journal of Geo-Marine Sciences, Vol. 39 (4) 597-604. December 2010.

60 Ibid.

61 Ibid.

Gopalpur port, Odisha

Gopalpur-on-Sea is a semi-urban town and an important tourist site on the south Odisha coast. An open coast seasonal port was constructed in 1987 by excavating the basin on the backshore. The beaches at Gopalpur were experiencing active erosion during the 2007 south-west monsoon period. Major erosion took place on the southern side beaches of Gopalpur town. At some places the vertical cut was about 3 m or more. During cyclonic events, sometimes the wave effect is strongly felt, and some of the hotels existing on the seafront have taken precautionary safety measures by constructing stonewalls, which has become more or less a regular activity every year.

The observation made by ICMAM-PD indicates that with the construction of two groynes at the entrance channel near Gopalpur port, the southern beaches are depositing and the beaches have accreted to the extent of nearly 200 m. On the other hand, the northern beaches are in a continuous state of erosion and there has been loss of about 120 m of the beach (Fig. 6.29). At present, the major changes are restricted to 1.5 to 2 km along the shore on each side of the groyne. The proposed expansion of the port with breakwaters on the southern side will aggravate erosion. Unless remedial measures are taken the beaches of the fishing villages located 2 to 3 km from the port will face erosion, depriving the fishermen of facilities for landing their boats.

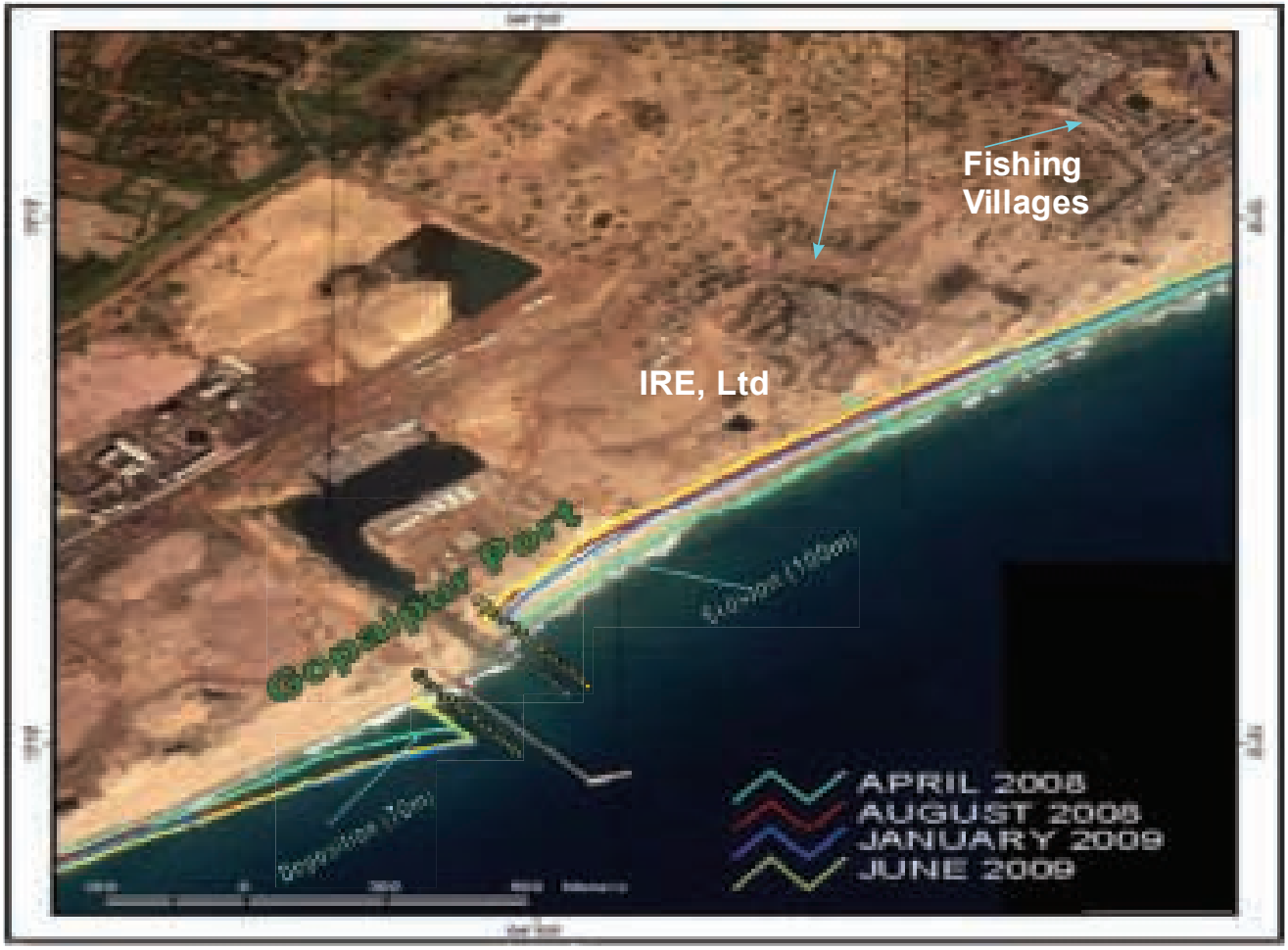


Figure 6.29: Temporal changes of the shoreline showing beach buildup and erosion. (Source: MoES[62]).

Paradip port, Odisha

At the port of Paradip the triggering of coastal erosion due to obstruction to the littoral drift is clearly evident. The construction of two breakwaters has caused accretion on the southern side and erosion on the northern side. A sand pump on a trestle constructed south of the south breakwater had been installed, so that the material

62 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

accumulating on the southern side could be pumped across to the eroding northern beach. However, there were problems in operating the pumps and the trestle was damaged during a cyclone in 1972. This resulted in short supply of sand to the northern beach, causing erosion. A seawall of about 5 km length was constructed from the root of the northern breakwater along the coast to prevent erosion of the shoreline. Though the seawall has been found to be successful to a certain extent in preventing the landward encroachment of the sea, reflection of waves caused scouring at the toe of the seawall. The effect of erosion can be seen in deepening/scouring of the coast, which has resulted in shoreward shifting of the -3 m and -5 m depth contours (Fig. 6.30)[63].

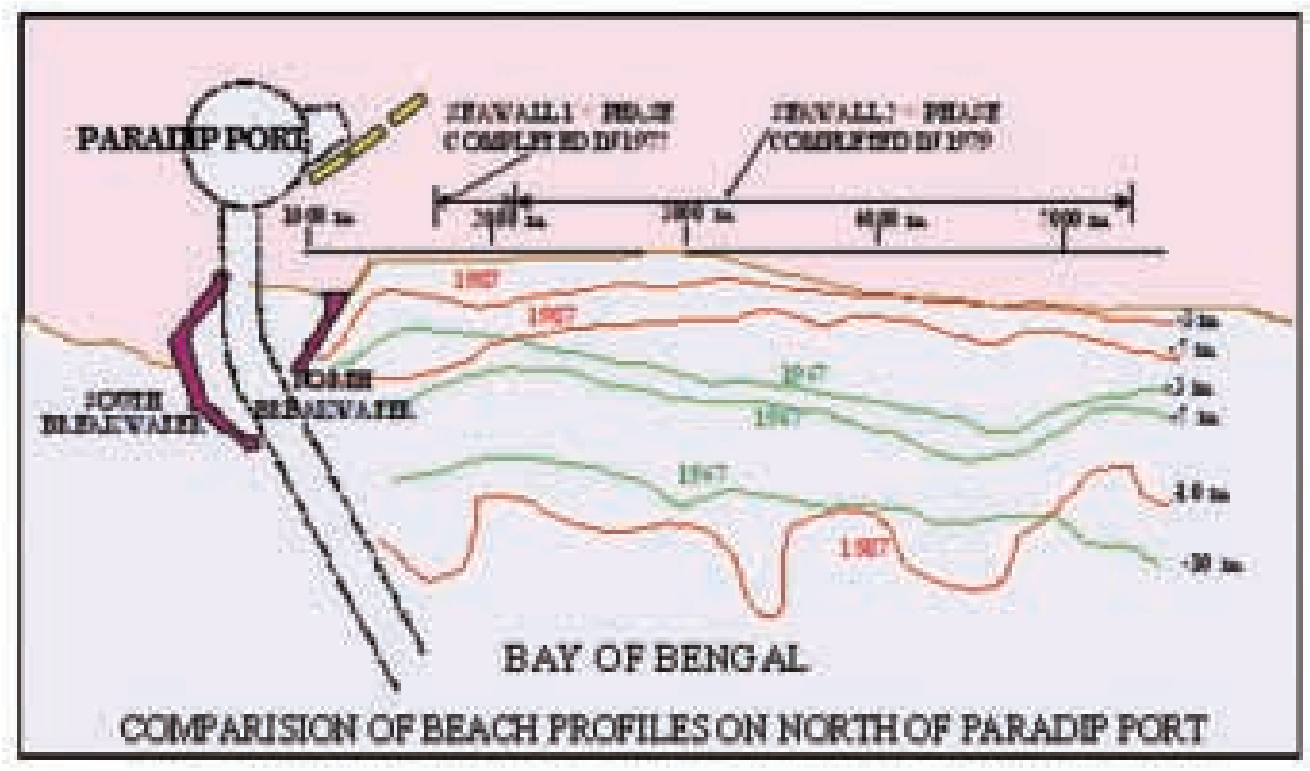


Figure 6.30: Increase in depths on northern coast of Paradip port. (Source: Kudale, M.D.[64]).

West Coast:

Mangalore inlet at harbour on Ullal-Bengre coast, Karnataka

The Mangalore estuary inlet was migrating naturally for several decades until two rubble-mound breakwaters (river training jetties) were built in 1994 to allow safe navigation of boats. Due to the construction of breakwaters, the migration of the river mouth stopped. But on the other hand, since the year 1996 it has led to severe coastal erosion during the monsoon months at the south of the southern breakwater. However, the major part of the beach regains again during non-monsoon months[65].

The erosion is visible on the barrier spit over a length of 1.4 km of land that is connected to the main land at the southern end. During the monsoon, this erosion represents a potential threat to open another mouth.

The shoreline changes have been studied at monthly, seasonal and annual intervals using remote sensing (1997-2002) and field data (2004-2006)[66]. Beach profiles and shoreline positions were monitored for 2 years to estimate the seasonal pattern of accretion/erosion and movement of sediment around the mouth. (Fig. 6.31).

63 Kudale, M.D., Impact of port development on the coastline and the need for protection - Indian Journal of Geo-Marine Ssciences, Vol. 39 (4) 597-604. December 2010.

64 Ibid.

65 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

66 Ibid.

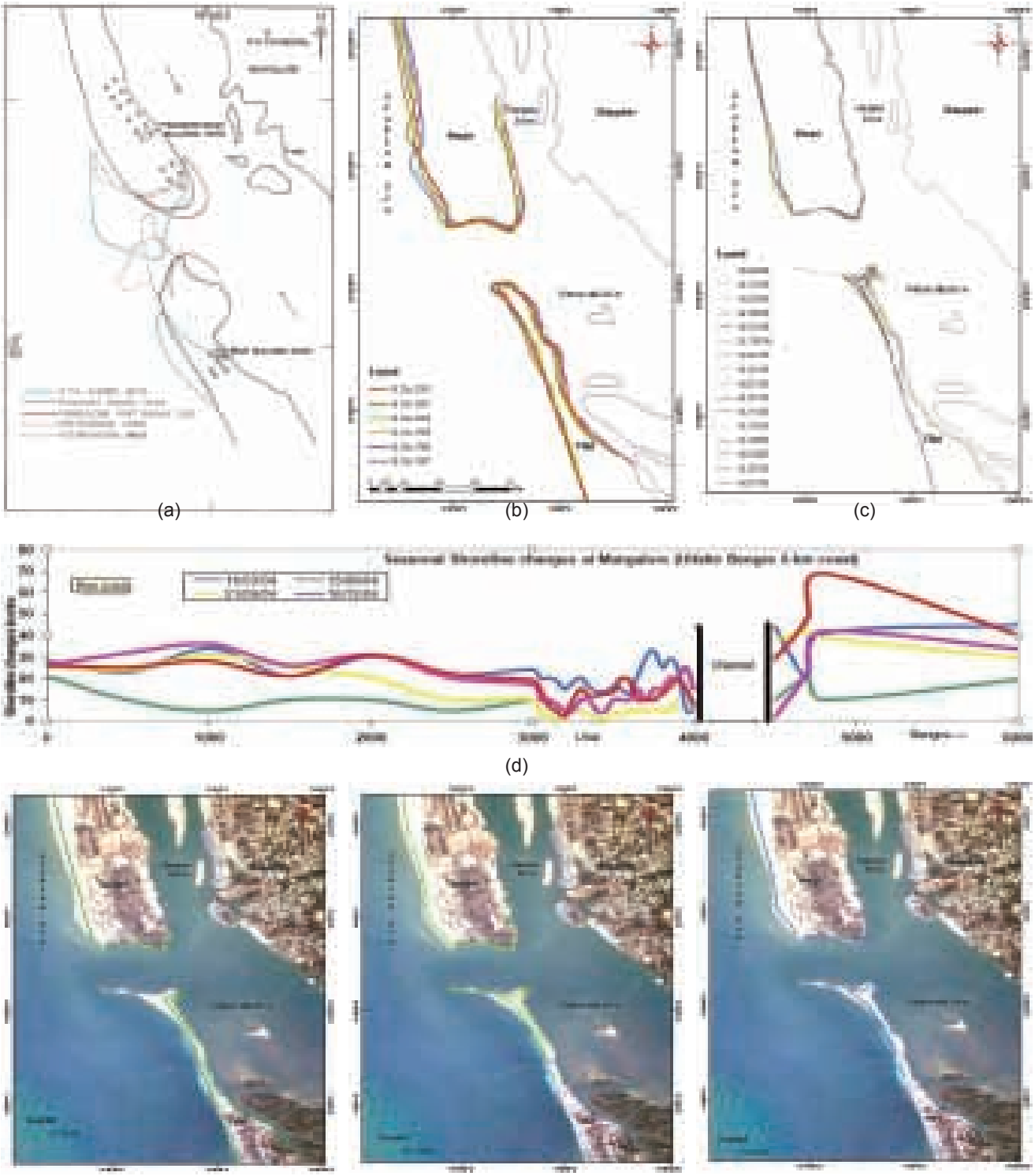


Figure 6.31: Shoreline changes (a) long term,(b) annual changes, (c) monthly changes (d) close view of seasonal fluctuations around inlet and e) overlay of satellite image. (Source: MOES[67]).

The study showed the occurrence of contrasting accretion and erosion patterns around the inlet i.e. the north (Bengre) and south (Ullal) spits of the inlet. Ullal beach faces severe erosion during monsoon months, and regains 90% of sediment during the fair season. The Bengre (northern) area accretes during monsoon months due to sand supply from rivers and suffers erosion during fair weather. The net erosion was 0.06 million

67 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

cubic metres along Ullal and 0.25 million cubic metres accretion along Bengre during the period March 2004 to March 2005. The analysis of remote sensing data revealed that wide fluctuation in shoreline (35-60 m) took place at a seasonal scale due to monsoon conditions. However, net annual changes indicate marginal erosion (0-10m) at Ullal and accretion (0-20m) at Bengre[68].

Kayamkulam inlet on Arattupuzha coast in Kerala

The Arattupuzha coast just north of the Kayamkulam inlet has been undergoing severe erosion. The width of the land between the sea and the backwater is considerably reduced along the Arattupuzha coast. From the long term shoreline change maps, it can be summarized that during the 15 year period 1985-2000 erosion was dominant in the Thottapally - Alleppey sector, as shown in Fig. 6.32[69]. Both sides of the Kayamkulam inlet show erosion.

Two breakwaters were constructed for safe navigation to support the fisheries sector in the year 2000. From field visits made to the site, it is seen that this scenario has changed considerably since the year 2000, along with progress of the construction of the breakwater at the inlet. The breakwaters constructed at the inlet for a fishing harbour have resulted in accretion towards the south of the inlet and increased erosion on the northern side. The record accretion at Puthuvype region gives rise to a spectacular accretion of 396 ha in the Vypin – Munambam zone.[70]

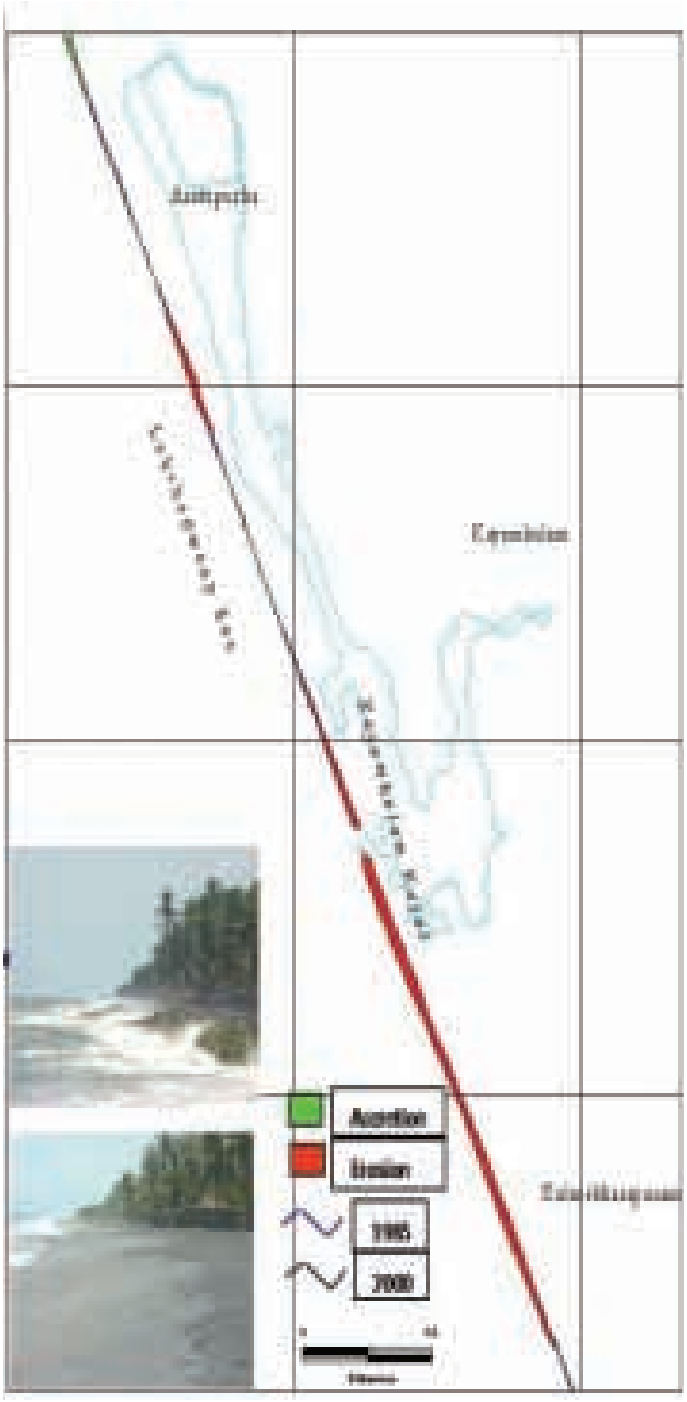


Figure 6.32: Location of Arattupuzha and observed accretion & erosion areas 1985 - 2000. (Source: MOES[71]).

68 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to MoEF by ICMAM Project Directorate and INCOIS, Hyderabad, MoES, Government of India.

69 Ibid.

70 Ibid.

71 Ibid.

Development in Mirya Bay, Ratnagiri, Maharashtra

Mirya Bay in Ratnagiri, which was considered to have excellent conditions for port development due to stable bed conditions in the main bay, with depths of more than 8 m, was used for development of a commercial harbour and fishing harbour. Breakwaters were built at the southern tip of the bay for the development of Bhagwati Bandar harbour. No major siltation occurred after the construction of the breakwaters. Additionally, a fisheries harbour with two breakwaters was developed in the south-east region of the bay on a sandy beach. As a result of the construction of the breakwaters for the fishing harbour, excessive accumulation of sand has occurred to the north of the northern breakwater and the approaches to the fisheries harbour are getting silted up (Fig. 6.33). On the other hand, severe erosion has occurred in the northern portion of the bay.

Figure 6.33: Imagery of Mirya Bay, Ratnagiri. (Source: Kudale, M.D.[72]).

Concluding remarks:

In various parts of the country's coastline, both on the eastern and western coasts, harbours and their associated structures – breakwaters, training walls, navigation channels, etc – have caused and are still causing the shoreline to change. In most instances, the coast in the proximity of artificial harbours is destabilized. This results either in accretion or erosion of the coast. While accretion of the coast is sometimes viewed as a positive impact, it can however have negative impacts too, such as the silting up of the mouths of rivers, estuaries or creeks and harbours. Erosion of the coast on the other hand more often than not results in negative impacts, causing loss of natural habitat, the beach space that is required for coastal processes, and the livelihoods of coastal communities. The unnatural destabilization of the coastal environment that is caused by harbours is a threat to the coastal environment, to the ecology, and to the coastal communities. When the coast becomes unstable it becomes increasingly vulnerable to both natural and man-made factors. It is therefore found that the increased vulnerability of the coastal environment and the development of harbours are very often closely inter-related.

72 Kudale, M.D., Impact of port development on the coastline and the need for protection-Indian Journal of Geo-Marine Ssciences, Vol. 39 (4) 597-604. December 2010.

7. Legislation for Coastal Protection

In spite of all the laws that are in place, there are few instances where someone has been penalized or punished for violations or for not mitigating the damage caused to the environment.

7.1. The CRZ

India has a framework law to protect the environment called The Environment (Protection) Act, 1986. It empowers the Central Government to establish authorities [under section 3(3)] charged with the mandate of preventing environmental pollution in all its forms and to tackle specific environmental problems that are peculiar to different parts of the country.

The concern about the need to preserve and conserve the coast initiated by the then Prime Minister Smt. Indira Gandhi in the early nineteen eighties resulted in the promulgation of the Coastal Regulation Zone Notification in 1991, under the Environment (Protection) Act, 1986. This notification defined the prohibited, permitted and regulated activities in a 500 metre stretch from the high tide line after classifying the coast into four zones (broadly: ecologically sensitive areas, built up areas, rural areas and islands). In the succeeding two decades, it was amended over 25 times.

In 2005, a committee chaired by Prof. M. S. Swaminathan brought out a report recommending a move towards integrated coastal zone management and the replacement of the CRZ Notification with the Coastal Management Zone Notification[1]. The draft CMZ Notification resulted in extensive protests by coastal communities, especially the fishing communities, across the country, saying that this would result in the rampant development of the coast and the complete loss of livelihoods of the fishing community.

In 2009, a committee once again chaired by Prof. Swaminathan brought out another report called the **Final Frontier**[2]. This report urged the lapse of the draft CMZ Notification and suggested keeping the CRZ 1991 Notification as the basic framework, subject to suitable changes being incorporated to take into account the needs of coastal communities and the growing pressure of population and development activities on coastal resources and biodiversity, as well as new threats due to climate change related devastations such as increasingly severe cyclones, storm surges and sea level rises. The committee pointed out that testimonies from fishermen had described their struggle against the large development activities such as ports which had displaced their

1 MoEF, 2005. Report of the Expert Committee Chaired by Prof M.S. Swaminathan to review the Coastal Regulation Zone Notification 1991.

2 MoEF, 2009. Final Frontier. Agenda to protect the ecosystem and habitat of India's coast for conservation and livelihood security. Report of the Expert Committee on the draft Coastal Management Zone (CMZ) Notification, constituted by the Ministry of Environment and Forests, under the Chairmanship of Prof M S Swaminathan.

livelihoods and homes. In the Agenda for the Future, the Committee stated that there is need to: '***Introduce regulations to manage the proliferation of ports along the coasts, with possible impacts on the coastline, by considering cumulative impacts of these developments'.*** The Committee noted that 'currently, the shoreline of the country is undergoing a major change because of a large number of port and harbour projects. These projects involve large quantities of dredging, shore protection works, breakwaters and reclamation. The problem is that there is little information on the cumulative impacts of these projects on the coastline though it was clear that such developments have led to serious threats to the coast, with beaches facing severe erosion and shorelines changing'. The Committee suggested that the government should study the cumulative impacts of projects on the coastline, till which time there should be a moratorium on port projects.

7.2. The moratorium on ports

The MoEF then issued a temporary moratorium and asked the Ministry of Earth Sciences through the ICMAM Project Directorate to do a study of the state of the impact of port structures on the coastline. Based on a review of case studies, ICMAM made the following suggestions to MoEF[3]:

1. Avoid port structures etc at least 5 km on either side of eroding locations, as indicated in the report. Further, location of ports should be avoided around 10 km on either side of ecologically sensitive areas, estuaries and lagoons of biodiversity importance as accretion/erosion may lead to changes in morphodynamics of the inlets causing reduction in tidal water flow in the water body. Reduction in tidal exchange will adversely affect the biodiversity.
2. For other locations, especially for the locations selected to construct ports and harbours (the locations do not figure in the report), the status of erosion should be verified in consultation with the State Government. If found to be eroding areas, construction of ports and harbours at these locations should be avoided.
3. As an immediate measure, ports and harbours may be permitted in non-eroding locations confirmed by State Government. If the predictive models indicate that the impact of ports' structures may cause erosion/accretion, remedial measures must be part of the Environmental Management Plan to deal with the likely eroded and accreted areas.

7.3. Lifting of the moratorium on ports

Following this, the moratorium on port development was lifted with these strictures:

A. Expansion of existing ports and harbours, jetties, etc., within their notified port limits shall be undertaken subject to the condition that:
   (i) the hydro-dynamic studies indicate that the expansion activities of the existing port do not have significant impact on the shoreline abutting the project; and
   (ii) has no significant impact on the ecologically sensitive areas along the stretch.

B. New projects to be located at the sites indicated in Table 7.1, shall be subjected to Comprehensive Environment Impact Assessment, based on a minimum of 3 seasons data, and Environment Impact Assessment report prepared based on actual field measurements, appropriate modelling studies, etc.

C. With regard to the hotspot stretches viz. those areas which are prone to high erosion above 1 metre per year (identified by the concerned Central/State Government agencies), locations identified within 10 km on either side of the eco-sensitive areas categorized as Coastal Regulation Zone-I (i) and water bodies with high bio-diversity, shall not be considered for locating ports and harbours. However, fishing jetties/embarkation facilities for local communities could be set up with Environment Impact Assessment as per Environment Impact Assessment, 2006.

With respect to point B regarding appropriate modeling studies, it must be pointed out that considering the very unpredictable nature of the soil transportation process and the implicit lack of local site-specific data, modeling studies need to allow for large safety factors to limit risks of major environmental impact. In other

3 MoES, 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and Impact of Port structures on Shoreline changes. Report submitted to Ministry of Environment and Forests (MoEF). Integrated Coastal and Marine Area Management (ICMAM) Project Directorate and Indian National Centre for Ocean Information Services (INCOIS), Hyderabad Ministry of Earth Sciences, Government of India.

words, the likely evolution of the coastline with any new development might not have historical data upon which to base such studies. Extrapolating models/data from other regions would always have questionable validity due to the large variability and very unstable nature of sediment transport.

While the 'Final Frontier' had called for Cumulative Impact Assessment, the MoEF only asked for 'Comprehensive Impact Assessment' which is based on baseline data for three seasons. This in no way takes into account the cumulative impact of multiple activities on the coast. **Cumulative Impact** consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects in the same vicinity causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects[4,5]. This is important because of the recent trend in multiple industries, especially industries and ports being linked. The bigger issue is that EIA are usually completed within a short period, with little ground data and practically no public discussion. For example, an analysis of the EIA for the POSCO captive port showed that it looked just into the impact of the jetty alone[6]. The MoEF also commissioned the Institute for Ocean Management, Anna University, Chennai to map the shoreline change and mark the coast as a high/medium/low eroding/accreting area based on satellite imagery. The maps have been completed and accepted by the state governments for some of the states[7].

7.4. The EIA 2006 notification

India also has the Environmental Impact Assessment Notification (2006), under the Environment (Protection) Act, 1986 that outlines the required procedure for prior environmental clearance of development projects listed in the schedule of the notification. There are two categories of projects: Category A requires clearance from the MoEF while Category B projects can be cleared at the State level. In the case of ports, the notification says:

Table 7.1: Project categories for clearances from MoEF (A) or State Government (B)

Project or Activity	Category with threshold limit		Conditions if any
	A	B	
7e) Ports and Harbours	≥ 5 million TPA of cargo handling capacity (excluding fishing harbours)	< 5 million TPA of cargo handling capacity and/or ports/ harbours ≥10,000 TPA of fish handling capacity	General Conditions shall apply

General Conditions means that "Any project or activity specified in Category 'B' will be treated as Category A, if located in whole or in part within 10 km from the boundary of: (i) Protected Areas notified under the Wildlife (Protection) Act, 1972, (ii) Critically Polluted areas as notified by the Central Pollution Control Board from time to time, (iii) Notified Eco-sensitive areas, (iv) Inter-State boundaries and international boundaries".

The Coastal Regulation Zone Notification 2011[8], like its predecessor, allows ports and harbours in the CRZ as they require foreshore/waterfront facilities. Land reclamation, bunding or disturbing the natural course of seawater is generally not permitted except when:

(a) required for setting up, construction or modernisation or expansion of foreshore facilities like ports, harbours, jetties, wharves, quays, slipways, bridges, sealink, road on stilts, and such as meant for defence and security purpose and for other facilities that are essential for activities permissible under the notification;

(b) measures for control of erosion, based on scientific studies including Environmental Impact Assessment (hereinafter referred to as the EIA);

4 Walker, L.J. and J. Johnston. 1999. Guidelines for the Assessment of Indirect and Cumulative Impacts as well as Impact Interactions. European Union. http://europa.eu.int/comm/environment/pubs/home.htm

5 IL&FS 2010. Technical EIA Guidance Manual for Thermal Power Plants Prepared by IL&FS Ecosmart, Hyderabad for The Ministry of Environment and Forest, Govt. of India.

6 Mumtaz, Rifaz. Technical Evaluation of the EIA for the Captive Minor Port of POSCO – India Private Limited, Bhubaneswar, located at Jatadharmohan Creek near Paradeep in State of Orissa. CSE, New Delhi. 2010?

7 Shoreline change www.ncscm.org

8 MoEF, Government of India. Coastal Regulation Zone Notification 2011, published in the Gazette on 6 January 2011.

(c) maintenance or clearing of waterways, channels and ports, based on EIA studies;
(d) measures to prevent sand bars, installation of tidal regulators, laying of storm water drains or for structures for prevention of salinity ingress and freshwater recharge based on work carried out by any agency to be specified by MoEF.

Also prohibited are port and harbour projects in high eroding stretches of the coast, except those projects classified as strategic and defence related in terms of EIA notification, 2006, identified by MoEF based on scientific studies and in consultation with the State Government or the Union Territory Administration.

7.5. The CRZ 2011 and the fishing community

The CRZ 2011 is broadly similar to the CRZ 1991 in that it regulates activities in the 500 m zone from the high tide line, though there are many differences as well. The CRZ 2011 has a preamble where the objectives of the notification are given as "*to ensure livelihood security to the fisher communities and other local communities, living in the coastal areas, to conserve and protect coastal stretches, its unique environment and its marine area and to promote development through sustainable manner based on scientific principles taking into account the dangers of natural hazards in the coastal areas, sea level rise due to global warming*". That the rights of traditional fishing communities and other coastal communities are to be protected is mentioned in many places. The important differences are that while CRZ I-III are the same as in the 1991 notification, CRZ IV, which dealt with islands in the 1991 notification, includes the water and seabed up to 12 nautical miles from the shore in the 2011 notification. A separate notification for regulating development activities in the islands has also been brought into force. With respect to the spaces used by the fishing community, Annexure –I which provides the guidelines for preparation of the Coastal Zone Management Plans (CZMP), says that: "*In the CRZ areas, the fishing villages, common properties of the fishermen communities, fishing jetties, ice plants, fish drying platforms or areas infrastructure facilities of fishing and local communities such as dispensaries, roads, schools, and the like, shall be indicated on the cadastral scale maps. States shall prepare detailed plans for long term housing needs of coastal fisher communities in view of expansion and other needs, provisions of basic services including sanitation, safety, and disaster preparedness*". Recognition has also been given to the fact that fisherfolk live close to the shore for pursuing their livelihood, and hence such townships are to be improved with infrastructure facilities such as sanitation and waste disposal.

7.6. Legislation to protect biodiversity

The Wildlife (Protection) Act, 1972 (WPA or WLPA) provides protection to wildlife habitats in protected areas and to wildlife species listed in its six schedules, depending upon their conservation status. India now has four legal categories of Protected Areas (PA): National Park (NP); Wildlife Sanctuary (WLS); Conservation Reserve and Community Reserve (CmR). The national park provides for the highest level of legal protection and prohibits any consumptive utilization of land or natural resources. In a wildlife sanctuary some form of resource utilization may be permitted to meet the needs of local people in a manner that is compatible with conservation of its biological values. India has also established Tiger Reserves, Elephant Reserves and Biosphere Reserves which are management entities and their whole areas or different management zones may be notified as one or the other of the aforesaid legal categories[9]. Marine protected areas in India comprise national parks and wildlife sanctuaries and cover coastal wetlands, especially mangroves, coral reefs and lagoons and have been notified under the WLPA. Fifteen Category I areas are located on the mainland in the states of Gujarat, Maharashtra, Tamil Nadu, Andhra Pradesh, Odisha and West Bengal. 10 PAs on the mainland have terrestrial or freshwater ecosystems which constitute boundaries with seawater or partly contain marine environment but are not listed as MPA as per criteria.[10]

Ecologically Sensitive Areas (ESAs) have been identified and notified by the Indian Ministry of Environment & Forests (MoEF) since 1989 under the Environment (Protection) Act 1986. Two such coastal areas have been

9 Mathur, V.B. Protected Area Management in India: Issues and Challenges. Presented at the Vth Brazilian Congress on Protected Areas, Foz do Iguacu, June 17-21, 2007.

10 Singh, H.S. Marine Protected Areas in India. Indian J. Marine Sciences. 32(3) 2003: 226-233.

notified: Murud-Janjira and Dahanu[11]. Under the Coastal Regulation Zone (CRZ) 1991 Notification and the subsequent CRZ 2011 Notification issued under the Environment (Protection) Act, CRZ-I includes Ecological Sensitive Areas such as mangroves, corals and coral reefs and associated biodiversity, sand dunes, mudflats which are biologically active, national parks, marine parks, sanctuaries, reserve forests, wildlife habitats and other protected areas under the provisions of Wildlife (Protection) Act, 1972 (53 of 1972), the Forest (Conservation) Act, 1980 (69 of 1980) or Environment (Protection) Act, 1986 (29 of 1986); including Biosphere Reserves, salt marshes, turtle nesting grounds, horseshoe crabs habitats, seagrass beds and nesting ground of birds. No new construction is supposed to be permitted in these areas.

In addition, CRZ 2011 talks about Critically Vulnerable Coastal Areas (CVCA) identified under the Environment (Protection) Act, 1986, and managed with the involvement of coastal communities, including fisherfolk. Such areas include the entire Sunderbans mangrove areas and other identified ecologically important areas such as Gulf of Khambat and Gulf of Kachchh in Gujarat, Malvan, Achra-Ratnagiri in Maharashtra, Karwar and Coondapur in Karnataka, Vembanad in Kerala, Gulf of Mannar in Tamil Nadu, Bhaitarkanika in Odisha, Coringa, East Godavari and Krishna in Andhra Pradesh.

11 Kapoor, M., K. Kohli and M. Menon. India's Notified Ecologically Sensitive Areas (ESAs): the story so far. Kalpavriksh, New Delhi & WWF-India, New Delhi. 2009.

8. Overview of the state of development of the Indian coast

The oceans are in trouble; the coasts are in trouble; our marine resources are in trouble. These are not challenges we can sweep aside.

8.1. Introduction

India's total coastline is said to be around 7,500 km, of which the mainland coast is about 5,700 km and the island territories contribute the rest. This is less than 0.25% of the world coastline, but 17% of the world's population according to the 2011 census lives in India. Of this number, over a quarter live within 50 km of the coast. The Indian coastline is therefore one of the most densely populated in the world.

In this study, the several islands just off the mainland except for Rameshwaram and Diu – which are for all practical purposes part of the mainland in terms of development activities and pressures – as well as the island states of Andaman & Nicobar and the Lakshadweep, have been excluded from this study. This is not because they are of less significance in terms of biodiversity and livelihoods – on the contrary they are even more significant than many parts of the mainland in this regard – but because: (a) as this is a preliminary assessment and study, the first of its kind, due to the limited time and funds available the task was simplified and was limited to the mainland of India; and (b) the history, modes and pressures of development and the challenges that are present on the mainland are significantly different from those faced on the islands. Based on the findings and lessons learnt during this preliminary study it is proposed to expand the scope to include all of India's islands.

One of the issues faced during the survey, that was conducted during this study, was the definition of the length of mainland India's coastline. In addition to the oft-quoted figure of 5,700 km, there are several other coastal lengths that have been indicated in the literature, ranging from a length of about 5,400 to 7,300 km. This is illustrated in table 8.1 and the detailed district-wise measurements are provided in Annexure III. As it is almost impossible to define the exact length of the coastline due to the phenomenon of "coastline paradox"[1], for this study's survey we have measured the length of the path along the coastline that we have followed in "Google Earth" during our survey, at a scale at which the features that we were looking for (structures, settlements, water bodies, etc.) were visible and measurable. The length of this path, which is about 6,700 km, is therefore, for practical purposes, referred to as the length of the coastline that we have surveyed. This is found to be barely 15% more than that provided by NATMO, the major differences

1 Weisstein, Eric W. "Coastline Paradox." From MathWorld-- A Wolfram Web Resource. http://mathworld.wolfram.com/CoastlineParadox.html

occurring in the state of Gujarat, Maharashtra and West Bengal, which have the most non-linear parts of the coastline.

Table 8.1: Lengths of mainland India's coastline in literature and surveyed during this study.

	Length (km)			
State	**NATMO[a]**	**ICMAM[b]**	**CSO[c]**	**Surveyed[d]**
Andhra Pradesh	987	974	960	1,016
Daman and Diu	26	10		34
Goa	153	151	300	201
Gujarat	1,408	1,215	1,600	1,667
Karnataka	293	280	400	325
Kerala	564	570	1014	593
Maharashtra	666	652	840	901
Odisha	479	476	560	518
Puducherry	32	31		46
Tamil Nadu	911	907	720	978
West Bengal	181	158	950	388
Grand Total	**5,700**	**5,424**	**7,344**	**6,667**

(a) National Atlas and Thematic Mapping Organization. http://natmo.gov.in/

(b) ICMAM & INCOIS, MOES. 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and impact of port structures on shoreline changes.

(c) Central Statistical Organization. 2000. Compendium of Environment Statistics. Ministry of Statistics and Programme Implementation, Govt. of India.

(d) Length of the path that was followed in "Google Earth" along the coastline during the study and survey.

As the coastal length of 5,700 km referred to by NATMO is a length that has been obtained with a well-defined projection and datum, we shall use this measurement along with the length of 6,700 km (approximately) of the coastline that we have measured and covered during our survey when necessary. When dealing with parts of the coastline of states where the difference between the length provided by NATMO and the one surveyed by us is small, we shall refer to the length of the coastline surveyed by us.

On the Indian mainland, there are 9 states and 2 union territories with a coastline. From west to east these are: Gujarat, Daman & Diu (UT), Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu, Puducherry (UT), Andhra Pradesh, Odisha and West Bengal. There are 73 coastal districts (Out of a total of 593). Depending on the lengths of the coastline considered, the east and west coasts occupy 43% to 45% and 55% to 57% respectively of the coast of mainland India. Either way, the west coast of India is longer than the east coast. A total of 77 cities and towns are located on the coast, including the urban agglomerations of Mumbai, Chennai and Kolkata and the rapidly expanding cities of Kochi and Visakhapatnam.

The physical regime of the Indian coast is characterized by a variety of geomorphological features ranging from open beaches and estuaries to bays and marshy lands. The west (Arabian Sea) coast differs considerably from the east (Bay of Bengal) coast in a number of features: the west coast has a wide continental shelf and has rocky shores and headlands, whereas the east coast with a narrow continental shelf is generally shelving with beaches, lagoons, deltas and marshes. The Arabian Sea experiences a strong upwelling associated with the south west monsoon, whereas the Bay of Bengal has only a weak upwelling. This results in marked differences in hydrographic regimes and productivity patterns, which in turn have an impact on the fisheries[2]. On the west coast there is the unique phenomenon of mud bank formation, areas of extreme calm, where fish and shrimp aggregate in large numbers. The amount of freshwater input into the east coast via the huge deltas is much

2 Venkatraman, K. and M. Wafar. Coastal and Marine Biodiversity of India. Indian J. Marine Sciences. 34(1) 2005: 57-75.

higher than the west coast. The east coast is also subject to severe storm surges which cause extensive damage due to coastal flooding, especially of the low lying areas.

This study looked at the space occupied by various developments and activities on the coast of mainland India. The landward extent was limited to 500 m of the shoreline, which is the CRZ area as defined by the Coastal Regulation Zone Notification (both CRZ 1991 and CRZ 2011). This is an approximation, as the standardized official marking of the high tide line is not available for the entire country as of now. Given that the length of the coast measured during our survey is 6,700 km, the area that falls in the 500 m zone adds up to about 3,350 km^2. The extent of the coast that is occupied by various developments and activities up to 500 m as mapped by this study is given in the tables under each topic.

8.2. Coastal ecosystems

Sandy beaches cover over 50% of the Indian coastline. The other major ecosystems include mangroves, mudflats, mangroves, salt marshes, coral reefs, seagrass beds and lagoons. There are 14 major rivers, 44 medium and a number of minor rivers, 97 major estuaries, 34 major lagoons, 31 mangrove areas, and 5 coral reef areas that have been mapped and identified in India for conservation and sustainable use[3]. Coastal wetlands are among the most productive ecosystems in the world, comparable to tropical rain forests and coral reefs. They are the "nursery areas" for many fish and shellfish species and are also important for keeping coastal waters clean. According to the inventory prepared by the Space Application Centre (SAC), out of a total of 27,403 wetland units in the country covering 7,581,871 ha, 3,959 were coastal wetlands occupying 4,022,956 ha of the land cover[4]. The area covered by each type of ecosystem is given in table 8.2.

Table 8.2: Extent of coastal ecosystems in India (Source: SAC)

Coastal Wetlands		Number	Area (ha)
Natural	Estuaries	97	153,966
	Lagoons	34	156,403
	Creeks	241	19,230
	Backwater	32	17,075
	Tidal/Mudflat	663	2,362,056
	Sand/Beach/Spit/Bar	772	421,019
	Coral Reefs	487	84,137
	Rocky Coast	85	17,686
	Mangroves	858	340,055
	Salt Marsh/Marsh Veg	161	169,840
	Other Vegetation	117	139,102
Man-made	Salt-pans	106	65,496
	Aquaculture ponds	356	76,891
Total Coastal Wetlands		3,959	4,022,956

India is one of the mega-biodiversity countries of the world, but probably only about a third of the coastal habitats have been surveyed for biodiversity. While commercially important fin-fish and shellfish, many corals, larger reptiles and mammals have been inventoried, the databases are weak with respect to minor phyla and microbes[5]. 15,042 members of different taxa have been identified in India. These include 200+ diatoms, 844 macroalgae, 14 seagrasses, 39 mangroves, 486+ sponges, 3,498 crustaceans, 3,370 molluscs, 2,546 fish, 35 reptiles and 25 mammals[6].

3 Singh, H.S. Marine Protected Areas in India. Indian J. Marine Sciences. 32(3) 2003: 226-233.

4 An Inventory of Indian Wetlands. Sarovar Saurabh. Vol 1 (1), 2003. ENVIS-SACON.

5 K. Venkatraman, K. and M. Wafar. Coastal and Marine Biodiversity of India. Indian J. Marine Sciences. 34(1) 2005: 57-75.

6 Wafar M, K. Venkataraman, B. Ingole, S. Ajmal Khan, P. LokaBharathi P (2011) State of Knowledge of Coastal and Marine Biodiversity of Indian Ocean Countries. PLoS ONE 6(1): e14613. doi:10.1371/journal.pone.0014613.

8.3. Protected areas

Protected Areas along the coast were enumerated and mapped in this study. Tamil Nadu and Odisha have 4 Protected Areas each, but it is in West Bengal that the maximum percentage of the coastline is occupied by Protected Areas, both in terms of length of the coastline and the area up to 500 m as shown in table 8.3.

Table 8.3: Marine Protected Areas surveyed in this study

Marine Protected Areas							
State	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Andhra Pradesh	2	41.0	20.5	4.0	4.0	4.2	4.2
Daman and Diu	-	-		-	-	-	-
Goa	-	-		-	-	-	-
Gujarat	2	138.0	69.0	8.3	8.3	9.8	9.8
Karnataka	-	-	-	-	-	-	-
Kerala	1	-	-	-	-	-	-
Maharashtra	1	5.0	3.0	0.6	0.7	0.8	0.9
Odisha	4	102.9	51.5	19.9	19.9	21.5	21.5
Puducherry	-	-	-	-	-	-	-
Tamil Nadu	4	140.6	70.5	14.4	14.4	15.4	15.5
West Bengal	3	220.0	110.0	56.7	56.7	121.6	121.6
Grand Total	**17**	**647.5**	**324.4**	**9.7**	**9.7**	**11.4**	**11.4**

8.4. Water bodies

Not surprisingly, Kerala tops the list with 20.46% of the coastline occupied by water bodies, though it is in West Bengal that 14.84% of the total area in the 500 m zone is occupied by water bodies. Table 8.4 gives the state-wise details of water bodies as surveyed in this study.

Table 8.4: Water bodies surveyed in this study

Water Bodies								
State	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Andhra Pradesh	50	61	114.6	45.3	11.4	9.0	11.6	9.2
Daman and Diu	3	-	0.6	0.2	4.9	3.6	2.3	1.7
Goa	10	1	8.1	7.3	4.3	7.7	5.3	9.5
Gujarat	71	7	85.5	29.2	4.6	3.2	6.1	4.1
Karnataka	21	2	36.8	10.9	11.3	6.7	12.6	7.4
Kerala	67	6	122.2	22.8	20.5	7.7	21.7	8.1
Maharashtra	81	12	58.3	17.6	6.5	3.9	8.8	5.3
Odisha	12	20	66.4	26.0	12.8	10.0	13.9	10.8
Puducherry	4	3	3.8	1.2	8.9	5.9	12.0	7.9
Tamil Nadu	64	77	85.1	39.1	8.7	8.0	9.3	8.6
West Bengal	16	6	26.6	28.8	6.9	14.8	14.7	31.8
Grand Total	**399**	**195**	**608.0**	**228.4**	**8.9**	**6.7**	**10.7**	**8.0**

8.5. Settlements

A total of about 1,270 settlements were counted, occupying about 1,400 km or 21% of the coastline surveyed. This survey has only covered and counted those settlements that fall within the 500 m zone of the coast (as defined in the methodology in chapter 2). Settlements mapped in the study include fishing villages, hamlets, towns and cities. In several instances, settlements are beyond the 500 m zone and have therefore been excluded. It has not been possible to map the 3,288 fishing villages as per the CMFRI census. It must be mentioned that many of them may be located, for various reasons, beyond the 500 m contour that was mapped. These reasons could include inhospitable coastal terrain as in Gujarat, or villages up an estuary as in Odisha, or clustering of villages that make it look like a single uninterrupted unit whereas in reality it is made up of two or more distinct village units, as in some areas of Tamil Nadu. As mentioned in Chapter 4, fishing villages/hamlets use a fair amount of coastline and coastal space for many common activities like parking of boats, fish marketing, burial/cremation grounds, net mending, fish drying, recreational and cultural uses, etc. The extent to which such uses add to the length of coastline currently occupied is not easy to determine through Google Earth as these activities are often carried out without any identifiable/visible structures. The extent of the coastline occupied by settlements in the various states, ranked from largest to smallest, is given in table 8.5 as a percentage of the coastline of the state. Tamil Nadu with 309, and Kerala with 254, have maximum number of settlements along the coast. In these two states alone, about 725 km of coastline is occupied by settlements.

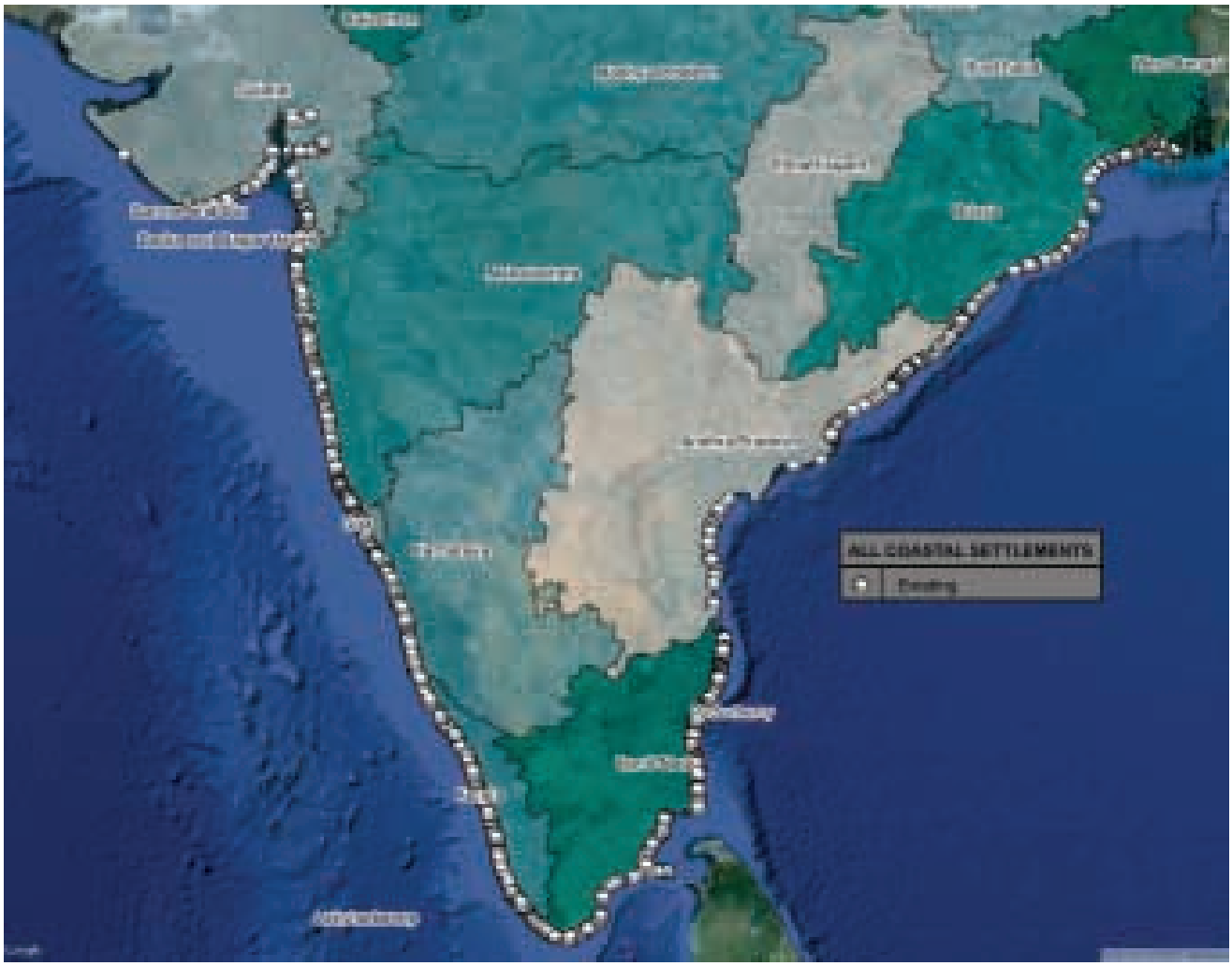


Figure 8.1: Settlements on the coast of India

Table 8.5: Settlements surveyed in this study

Settlements							
State	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Andra Pradesh	154	106.2	15.1	10.5	3.0	10.8	3.1
Daman and Diu	8	6.9	2.3	20.0	13.4	26.5	17.7
Goa	38	42.1	15.5	21.0	15.4	27.5	20.2
Gujarat	105	91.8	39.0	5.5	4.7	6.5	5.5
Karnataka	97	100.6	29.7	31.0	18.3	34.3	20.3
Kerala	254	218.6	68.4	36.9	23.1	38.8	24.3
Maharashtra	169	149.4	43.0	16.6	9.6	22.4	12.9
Odisha	60	66.7	16.1	12.9	6.2	13.9	6.7
Puducherry	20	12.6	3.4	27.0	15.0	42.0	23.0
Tamil Nadu	309	506.8	62.3	51.9	12.8	55.6	13.7
West Bengal	56	109.3	39.4	28.2	20.3	60.4	43.5
Grand Total	**1,270**	**1411.2**	**334.2**	**21.2**	**10.0**	**24.8**	**11.7**

8.6. Commercial areas

Commercial activities mapped in this study include (i) salt extraction, (ii) aquaculture, (iii) tourism activities like resorts, hotels,(iv) sand mining, (v) institutions and (vi) industrial activities. As it was difficult to identify commercial agricultural activities and their land use, this was excluded from the survey. Therefore the actual extent of coastal land within the 500 m zone that is used for commercial activities is much larger.

It is in Tamil Nadu that the maximum length of the coastline is used for commercial activities: about 220 km or 23% of the total coastline. The largest area within the 500 m that is occupied for commercial activities, as shown in table 8.6, is also in Tamil Nadu, which comes on the top of the list with 105.32 km^2 or 21.55% of the area up to the 500 m zone being occupied, whereas Andhra Pradesh has the maximum number of commercial areas (411). It is also the state with the highest percentage of its coastal zone (500 m zone) occupied by commercial activities and developments.

Table 8.6: Commercial areas surveyed in this study

Commercial Areas							
State	Total Nos.	Length Occupied (km)	Area Occupied (NATMO) (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Andhra Pradesh	411	201.9	80.1	19.9	15.8	20.5	16.2
Daman and Diu	5	4.1	0.6	11.9	3.2	15.8	4.2
Goa	77	19.1	4.4	9.5	4.4	12.5	5.7
Gujarat	76	76.4	81.1	4.6	9.7	5.4	11.5
Karnataka	52	16.6	2.0	5.1	1.2	5.7	1.4
Kerala	216	73.5	22.0	12.4	7.4	13.0	7.8
Maharashtra	135	49.6	10.0	5.5	2.2	7.5	3.0
Odisha	130	27.8	15.2	5.4	5.9	5.8	6.4
Puducherry	25	6.0	1.3	13.1	5.5	19.0	8.0
Tamil Nadu	358	220.9	105.3	22.6	21.6	24.3	23.1
West Bengal	86	17.7	2.0	4.6	1.1	9.8	2.3
Grand Total	**1,571**	**713.5**	**324.0**	**10.7**	**9.7**	**12.5**	**11.4**

8.7. Shoreline change along the Indian coast

As mentioned earlier, coastlines are dynamic and change depending to a great extent on the sediment transport along the coast. Rivers are the major source of sediments, and the annual discharge of sediments to sea along the Indian coast is about 1.2×10^{12} kg annually[7]. The estimated longshore sediment transport rates show that net transport along the east coast of India is towards the north, whereas along the west coast it is mostly towards the south. In small pockets the direction may be reversed[8]. Irrigation demands have led to the damming of many rivers and this has caused considerable reduction in the sediment load reaching the sea. Due to the fall in the influx of sediments and concentration of wave energy, many coastal stretches are getting eroded. Encroachment of sea into the land has been commonly noticed near river mouths, particularly along the coasts of Karnataka and Kerala and the Cauvery river mouth near Poompuhar, due to the reduction in sediment supply and discharge. This is also exacerbated by sand mining of river beds[9].

Erosion along the Indian coasts is not something new. In 1964, a study was carried out by the US Army Corps of Engineers on coastal erosion in India with special focus on Kerala[10]. The report indicated that in many places, even in the 1950s, localized shore protection measures were in place. The recommendation was that treatment of specific shore problems along the Kerala coast should be viewed in terms of an overall plan for stabilizing the state's shoreline and that the shoreline should be divided into littoral compartments. This is similar to the sediment cell concept that is being developed for shoreline management today[11]. In 1966, a Beach Erosion Board was constituted which was renamed in 1995 as the "Coastal Protection Development Advisory Committee"[12].

According to table 8.7, while about 23% of the Indian mainland coast was reported to be affected by sea erosion in 2004 (Iyer, 2004), the extent has gone up to 30% as per the latest available data[13]. The response to coastal erosion has been coastal armouring in the form of seawalls (usually rubble mound) and sand filled bags as an emergency temporary measure. Planning, investigation, design and execution of anti-erosion schemes are mainly the responsibility of the maritime state and union territory governments. However, the implementation of solutions is local, and often, perversely, the implementation of many of the anti-erosion schemes have themselves become primary sources of beach erosion at other locations further along the coastline.

7 Chandramohan, P. B.K. Jena and V. Sanil Kumar. 2001 Littoral drift sources and sinks along the Indian coast. Current Science 81(3): 292-297.

8 Sanil Kumar, V., K.C. Pathak, P. Pednekar, N.S. N. Raju and R. Gowthaman, Coastal Processes along the Indian Coastline. Current Science, 91 (2006): 530-536.

9 Ibid.

10 Watts, G.M. Coastal Erosion Study – State of Kerala, India. US Army Coastal Engineering Research Center, Washignton DC, 1964.

11 Integrated Coastal Zone Management Project. http://moef.nic.in/downloads/public-information/SICOM%20Brochure.pdf accessed 22 Aug. 12 .

12 Iyer, J.C. Coastal Erosion and Protection – A National Perspective. Workshop on Coastal Protection Measures. 5-6 Nov, 2004.

13 CPDAC, 2012. Statewise status of coastal erosion and protection. http://cwc.gov.in/CPDAC/index.html accessed 22 July 2012.

Table 8.7: State-wise distribution of eroded and protected coastline for mainland India

Sl. No.	State / UT	Length (km)	Type of coastline (% of total length)[1]				Length of coast affected by sea erosion (km)		Length of coast yet to be protected (km)		Coastline Protected (km)
Source		(NHO)	Sandy beach	Rocky coast	Muddy Flats	Marshy coast	2004 (Iyer, 2004)	CPDAC website	2004 (Iyer, 2004)	CPDAC website	CPDAC website
1	Gujarat	1,214.70	28	21	39	22	36.40	155[2]	32.40	132.70	22.30
2	Goa, Daman & Diu	160.50	44	21	35	-	10.50	19.18[3]	7.50	14.03	5.15
3	Maharashtra	652.60	17	37	46	-	263.00	263[4]	136.00	136.00	127.00
4	Karnataka	280.00	75	11	14	-	249.56	249.56[5]	212.16	192.79	56.77
5	Kerala	569.70	80	5	15	-	480.00	478.14[6]	111.52	131.39	346.75
6	Tamil Nadu	906.90	57	5	38	-	36.15	151.81[7]	27.95	76.19	75.62
7	Puducherry	30.60	-			-	6.40	9.495[8]	6.40	6.30	3.19
8	Andhra Pradesh	973.70	38	3	52	7	9.19	65.7[9]	8.70	45.25	20.45
9	Odisha	476.40	57		53	10	107.55	107.55[10]	97.55	97.55	10.00
10	West Bengal	157.50	-		51	49	49.00	125[11]	NA	44.20	80.80
	Total mainland	5,422.60	43	11	11	10	1,247.75	1,624.435	640.18	876.398	748.037

Footnotes

1 Sanil Kumar, V., K.C. Pathak, P. Pednekar, N.S. N. Raju and R. Gowthaman, Coastal Processes along the Indian Coastline. Current Science, 91 (2006): 530-536
2 As of Dec 2010
3 As of March 2010
4 Updated information awaited
5 As of Jan 2009
6 As of March 2010
7 As of Oct 2010
8 As of Dec 2010
9 As of Jan 2009
10 Updated information awaited
11 Updated information awaited Coastline protected information is up to March 05

Coastal erosion and related damage to settlements, infrastructure and livelihood are pervasive in the coastal states of India, especially in areas that are prone to natural hazards such as cyclones and tsunamis. Coastal protection measures adopted in India consist primarily of structural interventions i.e. groynes and seawalls, perhaps because they appear to provide protection faster. Table 8.6 gives state-wise details about the length of the coastline that is facing erosion as well as the length that has been protected (artificially). This is despite widespread belief that a combination of structural (e.g. seawalls, groynes, beach nourishment) and non-structural (e.g. mangroves and other shelter belts, setbacks) interventions could be more economical, environmentally and socially acceptable, and perhaps equally effective in protecting the coastline[14]. Casuarina as bioshields have been planted in long stretches of the coast. Mangrove plantations are relatively new but are steadily growing in importance because of their multiple benefits and better understanding of their coastal protection abilities, especially after the 1999 supercyclone that struck Odisha, and the 2004 Indian Ocean tsunami that devastated many areas along the east coast of India, especially Tamil Nadu. However, mangroves can be planted only in certain areas, whereas in others the preservation of the local natural ecosystem must be promoted.

While 25% to 30% of the Indian coastline is known to be eroding, the extent of natural and human induced erosion has not been found to be assessed. However, it is well established that several of the developments and activities that require structures to be built in the littoral zone have caused direct, human-induced erosion of the shoreline[15]. In developed countries such as the European nations, it was found that human-induced erosion of the coast has surpassed erosion that is driven by natural factors; it was found that human-induced erosion mainly proceeds from the cumulative and indirect impacts of projects, even small and medium ones, and from damming of rivers[16].

14 ADB, 2005. India: Integrated Coastal Management and Related Investment Development. Technical Assistance Report. Project No. 39135.

15 ICMAM & INCOIS, MOES. 2009. Report on use of satellite data for detection of violation of land use along the Coastal Regulation Zone and impact of port structures on shoreline changes.

16 National Institute of Marine and Coastal Management. 2004. A guide to coastal erosion management practices in Europe: lessons learned. Netherlands.

The management of coastal erosion in India has been limited to coastal defense. There are virtually no efforts aimed at mitigating or reversing the processes of coastal erosion, especially human-induced. Coastal restoration efforts have been unheard of in India until now. However, this is likely to change as the scientific community as well as the local communities come to understand the root causes of erosion as well as the importance of reversing the process of erosion through mitigation and restorative measures.

8.8. Coastal structures

A variety of structures have been constructed in the littoral zone and along the shoreline. These can be broadly classified into two categories: (i) as coastal defence against erosion, as in the case of seawalls, revetments and groynes; (ii) as infrastructure belonging to some associated development, as in the case of ports, power plants or large development projects that require structures like breakwaters, jetties, bridges, elevated roads, docks, etc. All of these structures occurring in the littoral zone were enumerated, measured and mapped, and are listed, state-wise, in tables 8.8 and 8.9.

The survey revealed that there are about 1,040 structures that have been built in the littoral zone of the coastline of mainland India. This amounts to an average of about one structure every 6 km of the coastline. The state with the maximum number of coastal structures is Kerala with a total of 281; an average of one nearly every 2 km of the coastline.

With regards to coastal structures that are linked to infrastructure of other development projects such as ports, power plants, or other large projects, the total number of structures is 380. Gujarat tops the list with 141 such structures or about 39% of the nation's coastal structures.

Table 8.8: Structures surveyed in this study

	Structures								
State	**Breakwater**	**Bridge**	**Detached Breakwater**	**Dock**	**Elevated Road**	**Jetty**	**Pier**	**Pipe Line**	**Grand Total**
Andhra Pradesh	9	-	2	2	-	6	8	1	28
Daman Diu	-	1	-	-	-	2	-	-	3
Gujarat	29	3	2	3	12	21	65	6	141
Karnataka	5	-	-	-	-	-	1	-	6
Kerala	24	-	-	-	-	3	13	-	40
Maharashtra	18	9	1	-	1	6	42	1	78
Orissa	2	1	-	1	-	1	-	1	6
Puducherry	6	1	-	1	-	1	-	-	9
Tamil Nadu	33	1	-	13	-	12	-	-	59
West Bengal	-	-	-	-	-	-	8	2	10
Grand Total	**126**	**16**	**5**	**20**	**13**	**52**	**137**	**11**	**380**
Total Length of Structures (km)	**86.8**	**10.6**	**4.6**	**6.3**	**19.8**	**39.2**	**29.0**	**3.5**	**202.8**

With regard to coastal structures meant for defence against coastal erosion, there are 480 seawalls and 204 groynes, amounting to 684 in all. These amount to an average of about one structure for every 8 to 10 km of the coastline of India. Once again Kerala tops the list with 171 seawalls and 70 groynes, amounting to 241 structures. On average there is one such structure for every 2.5 km of the coast. The total length of seawalls measured in this study (Table 8.9) runs to 517 km or about **7.6% of the coastline surveyed**. According to the study, Kerala has the maximum number of seawalls (171) covering 216 km and 36% of the total length of Kerala's coast and 42% of the seawalls built along India's shoreline. Surprisingly, almost 50% of the coastline of the tiny UT of Daman is armoured by 9 seawalls.

Table 8.9: Seawalls and groynes surveyed in this study

Seawalls & Groynes						
State	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (Natmo)	Total Nos. Groynes	Length Occupied (km)
Andhra Pradesh	4	3.7	0.4	0.4	5	1.2
Daman & Diu	9	6.1	17.7	23.4	-	-
Goa	4	3.6	1.8	2.3	25	3.1
Gujarat	108	117.9	7.1	8.4	10	6.9
Karnataka	20	16.8	5.2	5.7	70	5.7
Kerala	171	215.9	36.4	38.3	8	3.0
Maharashtra	86	58.3	6.5	8.8	2	0.9
Odisha	16	21.9	4.2	4.6	5	2.3
Puducherry	13	6.5	14.2	20.5	5	5.5
Tamil Nadu	33	28.7	2.9	3.2	49	11.0
West Bengal	14	27.2	7.0	15.0	4	0.6
Grand Total	**478**	**506.6**	**7.6**	**8.9**	178	**33.0**

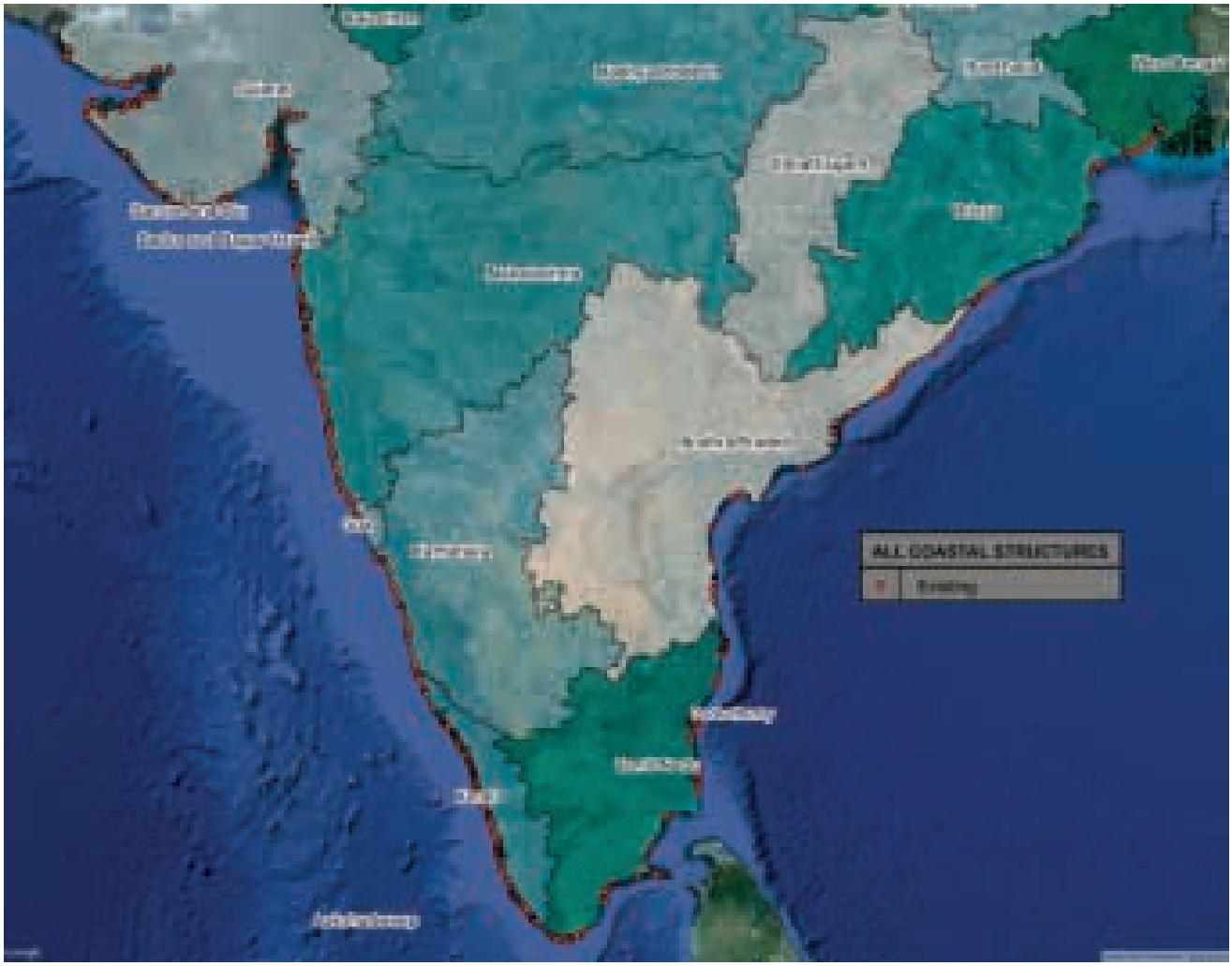


Figure 8.2: Structures on the coast of India

8.9. Ports and harbours

The status of ports in India: Maritime transport accounts for 90% by volume and 70% by value of the country's international trade. The total volume of traffic handled by all the Indian ports during 2009-10 was 849.9 million tonnes. The Indian port sector is broadly divided into two categories – there are 13 major ports (including one port at Port Blair, Andaman Islands, and the only corporate port at Ennore, Tamil Nadu) and 189 non-major (minor) ports in India, with the difference between the two being one of administration and not of size. Major ports come under the Ministry of Shipping, earlier called the Ministry of Surface Transport, MoST; minor ports, being on the concurrent list, are administered by the states, though they require environmental clearance from the Ministry of Environment and Forests. Not all the non-major ports are functional throughout the year or are active, but the share of the non-major ports in the overall traffic scenario is one of steady increase. The growth in cargo handled at major and non-major ports in 2009-10 was 5.8% and 35.4% respectively as compared to 2.2% and 3.3% in 2008-09[17].

Merchandise trade intensity of India's GDP is reportedly still below 30%, hence there is still a lot of untapped potential for trade growth. Hence, for quite some time there has been a call to expand ports in a timely manner. In August 2003, an ambitious plan called Sagar Mala was announced that proposed to cover all areas of maritime transport, including ports, shipping and inland waterways, and was aimed at realizing the potential of trade. The project envisaged the setting up of new ports along the coastline where required draught is available[18,19]. However, this project could not be processed to its finality, and instead in 2005 the National Maritime Development Programme (NMDP) was formulated by the Ministry of Shipping[20]. In June 2010, the government said that it would come up with a new plan that would replace the NMDP[21]. Poor infrastructure was cited as the cause for tardy progress of the NMDP. A detailed review about the growth of ports in recent times in India has been done by Rodriguez and Sridhar in 2010[22]. A state-wise distribution of port frequency along the coast has also been compiled by them and is reproduced here. In fact, the study has shown that distance between existing ports and newer ports can be as low as 14 km. They point out that at a national level there is a total lack of information on minor ports.

About 150 ports and harbours were identified, enumerated and mapped in the study (Table 8.10). All together, they are found to occupy about 115 km or 1.7% of the coastline and about 65 km2 or 2% of the total area that was surveyed in the CRZ. The table gives the extent of the coastline occupied by ports in the various states, ranked from largest to smallest, given as a percentage of the coastline of the state. The state of Maharashtra has the highest number of ports and harbours, numbering to about 44 that occupy about 37 km or 4.14% of the coastline. It should be pointed out that although the extent of the shoreline occupied by a harbour and the area occupied within the 500 m zone isn't very significant, the actual area of the port may extend well beyond the 500 m boundary on the landward side as well, apart from the water space occupied.

The Ministry of Environment & Forests (MoEF) has also determined that ports have an impact zone of about 10 km on either side and have therefore ordered that "with regard to the hotspot stretches viz. those areas which are prone to high erosion above 1 metre per year (identified by the concerned Central/State Government agencies), locations identified within 10 km on either side of the eco-sensitive areas categorized as CRZ-I(i) and water bodies with high bio-diversity shall not be considered for locating ports and harbours"[23]. For planning purposes therefore the area of impact of a port can be considered to be at least 20 km more than the land a port occupies along the coast. The area of impact of all ports along the coastline is therefore estimated to occupy approximately 3,000 km or 45% of India's coastline (or 53% according to NATMO).

17 GoI, 2011, Ministry of Shipping, Maritime Agenda 2010-2020.

18 Manoj, P. 2004. The Sagar Mala Project. Frontline, Vol 27, Issue 7. http://www.frontlineonnet.com/fl2107/stories/20040409003009800.htm accessed on 5 August 2012.

19 Commerce and Transport Department, Government of Orissa, Port Scenario in Orissa.

20 National Maritime Development Programme formulated, Sethusamudram Ship Channel Project Commissioned, Capacity addition in major ports during 2005 - Year End Review 2005. http://pib.nic.in/newsite/erelease.aspx?relid=14684 Accessed 6 August 2012.

21 PTI, 10-year maritime development programme on anvil: Govt. http://www.business-standard.com/india/news/10-year-maritime-development-programmeanvil-govt/98869/on Accessed 6 August 2012.

22 Rodriguez, S. and A. Sridhar. 2010. Harbouring Trouble: The Social and Environmental Upshot of Port Growth in India. Dakshin Foundation, Bangalore, p 62.

23 New policy on expansion of existing ports and initiation of new projects along the coastline. 3rd Nov. 2009. Press Bureau of India.

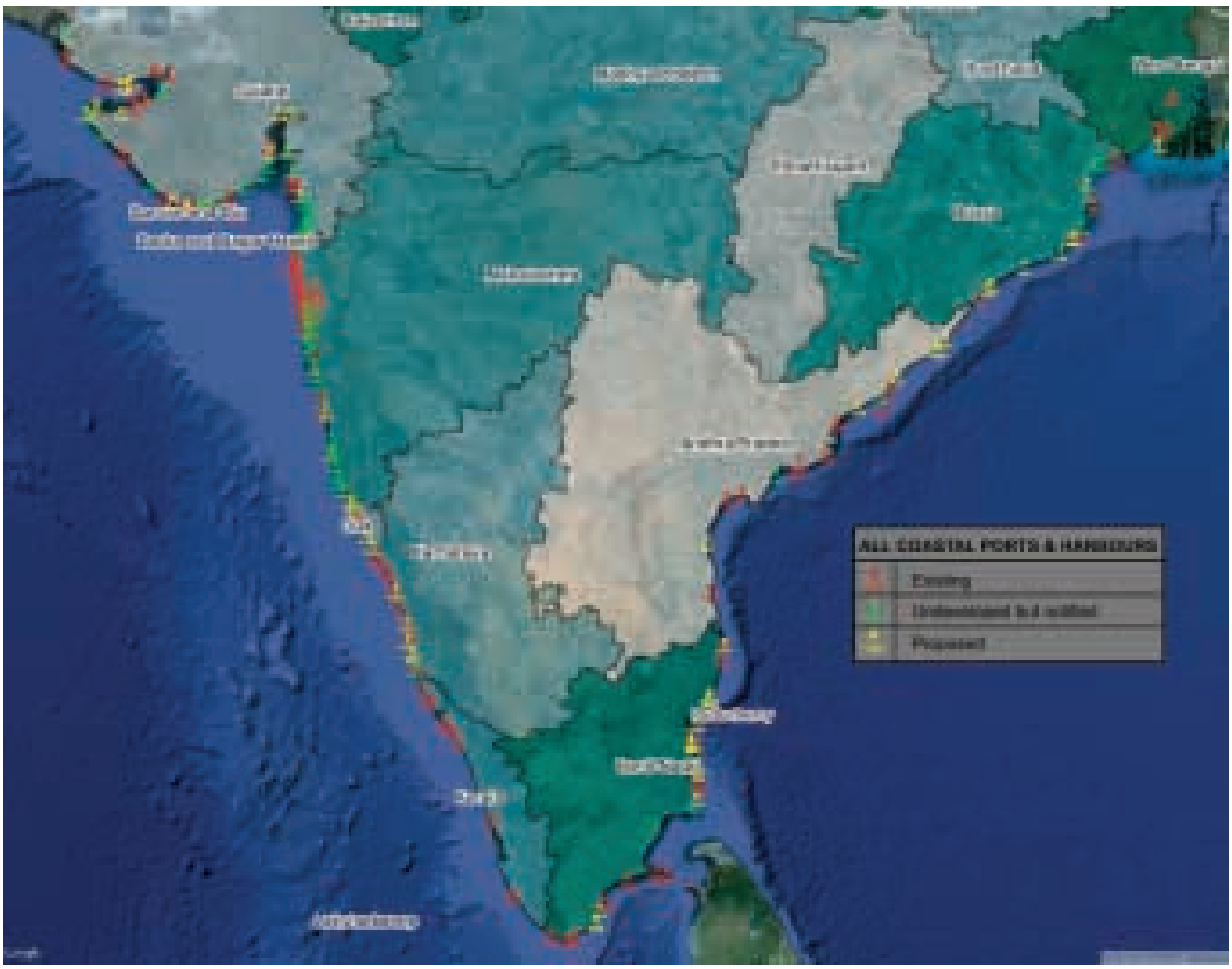


Figure 8.3: Ports

Table 8.10: Ports and harbours surveyed in this study

Ports & Harbours							
State	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Andhra Pradesh	13	5.6	2.5	0.6	0.5	0.6	0.5
Daman and Diu	1	0.5	-	1.5	0.1	1.9	0.1
Goa	6	4.5	0.8	2.3	0.8	3.0	1.1
Gujarat	32	29.7	13.0	1.8	1.6	2.1	1.8
Karnataka	10	6.1	1.7	1.9	1.1	2.1	1.2
Kerala	14	6.5	1.0	1.1	0.3	1.2	0.4
Maharashtra	44	37.3	11.9	4.1	2.6	5.6	3.6
Odisha	4	1.1	0.2	0.2	0.1	0.2	0.1
Puducherry	5	1.4	0.6	0.6	0.2	0.8	0.3
Tamil Nadu	19	19.4	27.6	2.0	5.6	2.1	6.1
West Bengal	2	3.1	5.7	1.1	4.1	1.7	6.3
Grand Total	**150**	**115.14**	**64.9**	**1.7**	**1.9**	**2.0**	**2.3**

A previous study had compiled the distribution of ports in mainland India, presented in table 8.11.

Table 8.11: State-wise distribution of ports and harbours on mainland India[24]

Name of State	Coastline (km)	Notified minor ports	Major ports	Port frequency (minor)*	Port frequency (total)*
Gujarat	1,214.7	49	1	24.8	24.3
Diu & Daman	9.52	2	0	4.8	4.8
Maharashtra	652.6	48	2	13.6	13.1
Goa	151	5	1	30.2	25.2
Karnataka	280	10	1	28.0	25.5
Kerala	569.7	17	1	33.5	31.7
Tamil Nadu	906.9	20	3	45.3	39.4
Puducherry	30.6	2	0	15.3	15.3
Andhra Pradesh	973.7	13	1	74.9	69.6
Odisha	476.4	14	1	34.0	31.8
West Bengal	157.5	1	1	157.5	78.8
TOTAL:	5,700	181			32.0

* Port frequency is the total coastline divided by number of ports

A state-wise percentage distribution of non-major ports is given in the figure below.

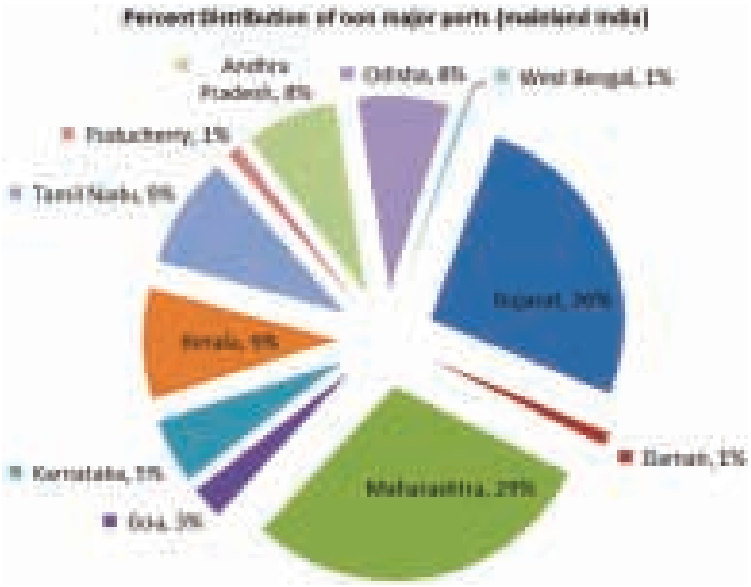


Figure 8.4: State-wise distribution of non-major ports and harbours (mainland India)

With regard to port frequency (average distance between ports or harbours along the shoreline), if we exclude Daman & Diu and Puducherry, territories which have a relatively tiny coastline compared to the other coastal states – a factor that skews the results for port frequency – we find that once again Maharashtra has the highest port frequency, with a port or harbor about every 20 km of the coastline. At the national level, the survey found that the port or harbor frequency is about one for every 50 km of the coastline. Port and harbor frequency according to data of table 8.11 is about one port/harbour for every 30 km of the coastline.

The difference between the number of ports or harbours recorded during the survey and those notified and listed in table 8.11 is because (a) some of the notified ports or harbours exist on paper but not on the ground; (b) some natural boat landing spots which have barely any visible infrastructure – therefore not recognizable as a port or harbour location in Google Earth – are notified ports, which therefore got missed out during the

24 Rodriguez, S. and A. Sridhar. 2010. Harbouring Trouble: The Social and Environmental Upshot of Port Growth in India. Dakshin Foundation, Bangalore, p 62.

survey; (c) some of the notified ports or harbours are located within creeks, estuaries or river mouths beyond the 500 m zone of the landward side of the littoral zone, and therefore beyond the zones of the coastline that were surveyed.

Proposals are on for the expansion of the existing ports and harbours as well as the addition of new ones. It was found that about 76 ports and harbours are proposed to be built. However details for proposed projects are not always readily available. A state-wise list of proposed ports and harbours is given in Table 8.12.

Table 8.12: State-wise distribution of proposed ports and harbours

State	Total
Andhra Pradesh	10
Goa	4
Gujarat	18
Karnataka	5
Kerala	5
Maharashtra	4
Tamil Nadu	17
West Bengal	3
Karnataka	1
Odisha	9
Grand Total	**76**

With the addition of 76 proposed ports and harbours to the existing 181 notified ones listed in table 8.11, the total number of ports and harbours could increase to 257, an increase of about 40%. With reference to the length of the coastline indicated in table 8.11, this would increase the port frequency to about one port or harbor for every 22 km of the coast. It should also be remembered that the Office Memorandum issued by the MoEF[25] states that "those areas which are prone for high erosion above 1 metre per year (identified by the concerned Central/State Government agencies), locations identified within 10 km on either side of the eco-sensitive areas categorized as Coastal Regulation Zone-I (i) and water bodies with high bio-diversity, shall not be considered for locating, ports and harbours". This factor must be seriously considered before deciding port or harbor locations, as with such frequency of ports and harbours along the coast as well as the rapidly increasing lengths of the coast facing erosion there will be no coastline remaining that would be outside the influence of the ports and harbours.

Environmental concerns do feature in plans of ports and many reports related to port activities. However, such concerns are mainly with regard to air pollution, mainly due to ships, and occasionally about noise and vibration, apart from oil spills, ballast water and bilge water disposal. There is relatively little discussion and awareness about the severe coastal erosion that the breakwaters of ports are causing and the large scale land use change that a port's existence entails. While the harbours per se occupy a relatively short length of the coastline – on an average less than a kilometre of the shoreline - the length of coastline that they impact, particularly in the form of shoreline change and erosion, is several times larger than the immediate area occupied by the port along the coast. The case study of coastal structures of Puducherry and neighbouring Tamilnadu (5.6) which covers the Puducherry harbour in chapter 5 showed how a harbour that barely occupies a few hundred metres of the shoreline has caused the complete destruction of about 7.5 km of the coastline, and the process of erosion is felt as far as 15 km away from the harbour.

A recent detailed report[26] assessing the impact of port development on the coastline concludes that sand bypassing i.e. dredging of sand from the up-drift side and artificial nourishment of the down-drift side, appears to be the best solution to mitigate the problem of siltation and erosion. Sand bypassing needs to be made mandatory for the port development projects and should form an integral part of the project at the planning stage itself. Sand removed during the capital and maintenance dredging operations can form a very good source of sand for beach nourishment to mitigate the adverse effects likely to be caused by the project. Most ports in India are not implementing any mitigation measure to counter erosion. The method presently used to counter erosion caused by ports and harbours is the construction of seawalls and groynes, which is only further aggravating

25 MoEF, GoI. New Policy on expansion of existing ports and initiation of new projects along the coastline. Office memo No.15-3/2009-IA-III dated 3rd Nov 2009.

26 Kudale, M.D., 2010. Impact of port development on the coastline and the need for protection. Ind. J. Mar. Sci. 39(4): 597-604.

the problem and resulting in increased destruction of coastal habitat as well as causing hardship by adversely affecting the livelihood of the coastal communities.

More often than not in India, the erosion of the coast caused and triggered by a harbour because of the disruption of the littoral drift is not handled by the port authorities, but is instead handled by other government agencies, usually the Public Works Departments (PWDs). The PWDs typically and conventionally deal with coastal erosion as a problem of flooding, and therefore try to address the problem with solutions that are meant for flood control, which is with the use of structures for coastal defence. The problem of erosion is most often dealt with in complete isolation of its root cause i.e. disruption of the littoral caused by the harbour, and therefore the solutions that are implemented are ad hoc and at best serve only as emergency, short-term measures that serve very localised purposes. Such measures usually result in greater erosion of the coastline, as they fail to address the principal causes of the problem, namely disruption of the littoral drift.

This problem is further exacerbated when the problem of erosion assumes inter-state dimensions. For instance, as described in the case study (5.6) of coastal structures in Puducherry and neighbouring Tamilnadu in chapter 5, the harbour that was built in the union territory of Puducherry has triggered erosion that has not only fully destroyed the beaches of Puducherry to the north of the harbour, but the erosion has also spread into the neighbouring state of Tamil Nadu, affecting several kilometres of the coast in the latter state and completely destroying 1.5 km of beaches. In this instance, the government and coastal communities of the territories in the state of Tamil Nadu adjacent to Puducherry are now completely dependent on the measures that are adopted by the Puducherry government for managing the coastline. Any measure that is going to disrupt the littoral drift will aggravate the problem of erosion in those adjacent territories in Tamil Nadu, no matter what the government of Tamil Nadu does to try to protect its shoreline.

Experience has shown that the problem of human-induced shoreline change and erosion tends to increase with time if it is not mitigated. With the increasing number of ports that are proposed to be developed along the Indian shoreline, some close to state boundaries, the inter-state dimension of these problems is only likely to grow. Without comprehensive, holistic and cumulative impact studies of port development, the impacts of such related activities, particularly with regard to coastal erosion, is only likely to increase.

Space occupied by ports: The size and scale of activities of a port decides its land requirement as well as the water spread. In the past, ships discharged directly onto land – that is, with limited space on the quayside, the port usually consisted of a narrow stretch of land along the waterfront. With increases in the size of ships and the extent of cargo handled, the demands for faster turn-around of ships, bulk handling modes and faster rates of loading and discharge have resulted in the need for large transit areas to provide a buffer between the capacity of land transport (rail and road links) and quayside handling facilities, as well as bigger cranes and gantries of various types, conveyor belts and so on. In addition, land is required for other port activities as well, such as residential complexes, power plants, sewage treatment systems, schools, hospitals and other infrastructure, special economic zones (the list is quite long). Thus, the **land area** occupied by ports has grown.

Take for example Visakhapatnam Port Trust (VPT). It has 4,368 ha, of which about 31% has been allotted to defence, 25.8% leased to port related activities, 16.4% is used by port's operational areas and so on. In the older ports, most of the area is allocated for port related activities (Table 8.13).

Table 8.13: Details of the major break-up of port land and land use of VPT[27]

Land Use	Hectares (ha)	Percentage
Land allocated to defence	1,345	30.8
Land leased for port based industries	1,128	28.8
Waterways of inner harbour	101	2.3
Land occupied by hills and nallas	441	10.1
Land for residential purpose	80	1.8
Land for port's operational buildings	20	0.5
Land for port's operational areas (docks, road, rail lines, stacking area, OHC)	716	16.4
Land leased to warehouses	87	2.0
Land proposed for lease to establish warehouses	60	1.4

27 Rotterdam Maritime Group and Tata Consultancy Services. Business Plan Project – Visakhapatnam. Final Report. 2007. http://www.vizagport.com/Doc/BPofVPT.pdf accessed 5 August 2012.

Information on the area occupied by the different major ports was compiled from various sources and is presented in table 8.14.

Table 8.14: Land area of major ports of mainland India

Location	State	Area (ha)
Visakhapatnam	Andhra Pradesh	4,206.00
Paradip	Odisha	2,832.80
Haldia	West Bengal	2,584.00
Ennore Port Ltd	Tamil Nadu	1,416.40
JNPT	Maharashtra	1,011.70
New Mangalore Port Trust	Karnataka	951.40
Kochi	Kerala	862.90
V.O.C Port, Tuticorin	Tamil Nadu	388.50
Chennai	Tamil Nadu	376.76
Kandla Port	Gujarat	98,743.00
Mormugao Port Trust	Goa	215.90
Mumbai	Maharashtra	46.30

There have been problems with land belonging to ports as well. In 2011, a land scam related to the Kandla port was exposed, the land being leased out at a pittance to salt manufacturing firms[28].

Newer ports are rarely standalone ports – apart from space for movement of goods and people, ancillary industries and port-based SEZ, there are even provisions for shopping malls and golf courses[29]. Coastal land is cheaper, because with hardly any clear ownership or land rights of individual communities, especially fisherfolk, the land is often declared as barren land 'owned' by the government, making it easier to acquire. Port proponents often acquire additional land during the planning stage itself. In some instances, port developers are also allowed to reclaim land from the sea by using the sand that is dredged to deepen the harbour as landfill material. In some instances, where land prices are prohibitively expensive, land reclamation might be cheaper than acquiring land. However, land reclamation with the use of sea sand has its problems, as it results in the subtraction of sediment from the sediment budget of a sediment cell. Such a removal of sediment from a cell is likely to result in erosion of the coast.

8.10. Power plants

For a country with growing energy demand, generation of power has become increasingly crucial. The total installed electricity generating capacity in India as on 30 April 2011 was 174,361 Megawatts (MW)[30]. Of this, coal-based capacity was 94,653 MW, while gas-based capacity was 17,706 MW, making the total thermal capacity 113,559 MW. A number of new power plants are in the pipeline, in various stages of the Environmental Clearance process of the MoEF, 84% of which are coal based projects. Many of these projects in the pipeline are geographically concentrated and include Nellore, East Godavari, Prakasam and Srikakulam in Andhra Pradesh, Kachchh in Gujarat, Tuticorin, Nagapattinam and Cuddalore in Tamil Nadu and Ratnagiri and Raigad districts in Maharashtra. Visakhapatnam and Cuddalore are already listed as critically polluted areas by the CPCB. From thermal power plants, an important problem is the release of sulphur dioxide (SO2). Flue gas desulphurization used to capture and remove SO2 is not mandatory in India. The second problem is disposal of fly ash. Indian coal has high ash content which is usually disposed of in ash ponds in the form of slurry or in ash dumps (dry). If the ash dyke breaches, large areas can be inundated with ash slurry. There is a policy on the reuse of ash by mixing it with cement in construction, but utilization appears to be lagging. Mercury emissions from coal fired plants can reach the aquatic ecosystems, undergo methylation and travel up the food chain, reaching humans and causing mercury poisoning.

28 Baweja, H. Gujarat: Land scam worth Rs 2 lakh crore exposed at Kandla port. Headlines Today, New Delhi, June 29, 2011. http://indiatoday.intoday.in/story/gujarat-land-scam-exposed-at-kandla-port/1/143100.html accessed 10 Sept 12.

29 Op. cit Rodriguez and Sridhar, 2010.

30 Dharmadikary, S and S. Dixit. Thermal Power Plants on the Anvil: Implications and need for rationalization. Prayas Energy Group Discussion paper, 2011. Prayas, Pune, India. www.prayaspune.org/peg

Table 8.15 lists 27 existing coastal power plants that were recorded during the survey. While the state of Gujarat has the maximum number of coastal power plants (8), Tamil Nadu has the highest frequency of power plants along the coast, one every 140 km.

Table 8.15: State-wise list of existing power plants (coastal) surveyed in this study

Existing Power Plants		
State	**Nos.**	**Capacity(MW)**
Andhra Pradesh	2	2,209
Goa	1	48
Gujarat	8	6,752.62
Karnataka	1	600
Kerala	2	516.58
Maharashtra	5	4,152
Pondicherry	1	32.5
Tamil Nadu	7	5,080
Grand Total	**27**	**19,390.7**

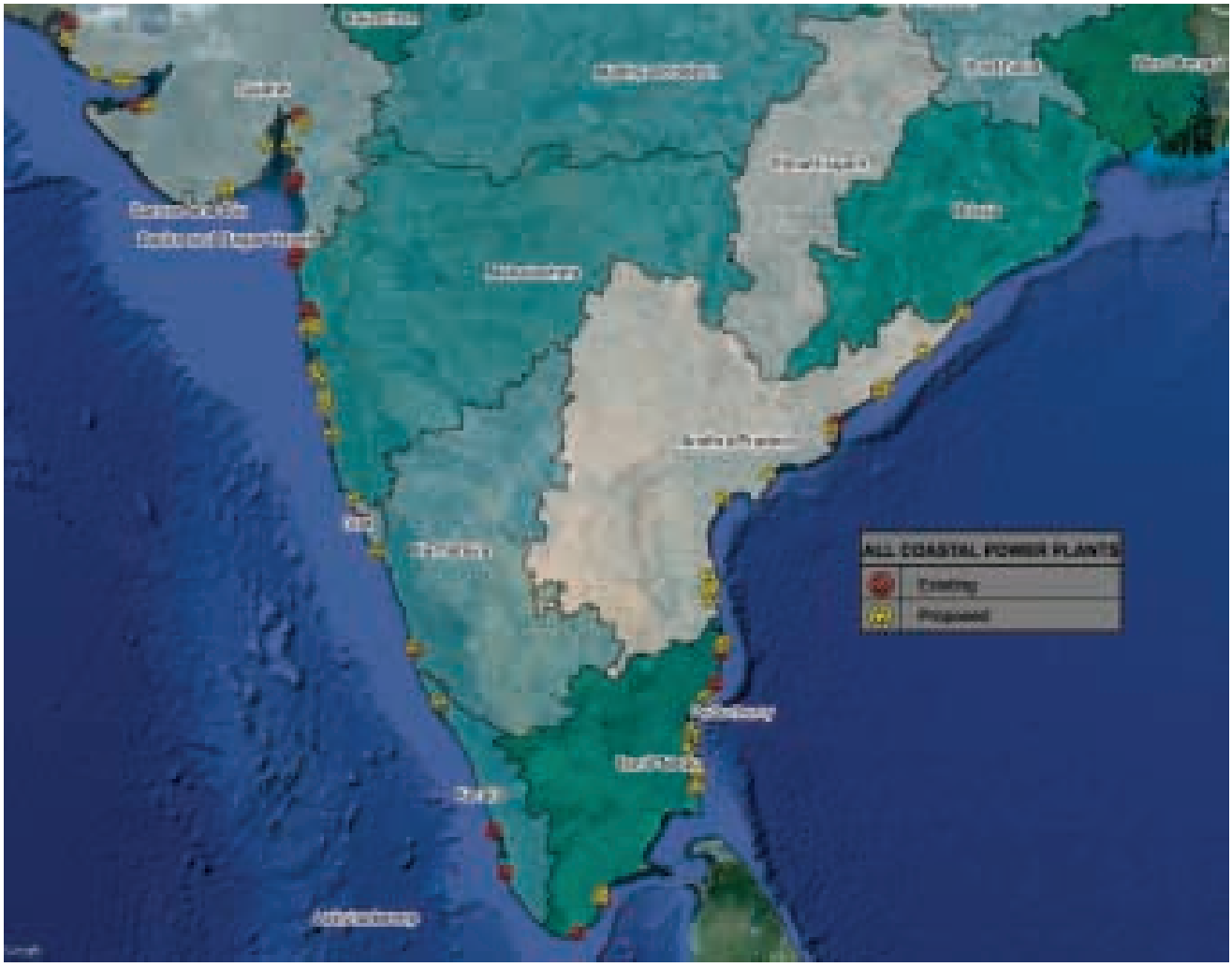


Figure 8.5: Power plants on the coast of India

Table 8.16 lists 59 proposed coastal power plants, over twice the number of those already in operation. In such a scenario the state of Tamil Nadu would have the largest number of power plants, 23 in number, and also the highest average frequency of power plants along the coast, one around every 40 km of the coast.

However, if we take into consideration the MoEF's general recommendation and guidelines for the siting of power plants, which states that they should be preferably located 5 km from ecologically and/or otherwise sensitive areas and at least 25 km from the projected growth boundary of settlements with populations larger than 300,000[31], their impact area significantly increases the area of the coastline occupied and affected by them. Though we are not in a position to quantify the extent of such an occupation and affected in this study, it would be safe to say that the coastline that is occupied by power plants is significant.

Table 8.16: State-wise list of proposed power plants (coastal)

Proposed Power Plants		
State	**Nos.**	**Capacity (MW)**
Andhra Pradesh	15	27,190
Gujarat	15	27,520
Karnataka	2	1,470
Kerala	1	1,320
Maharashtra	10	12,835
Tamil Nadu	16	21,690
Grand Total	**59**	**92,025**

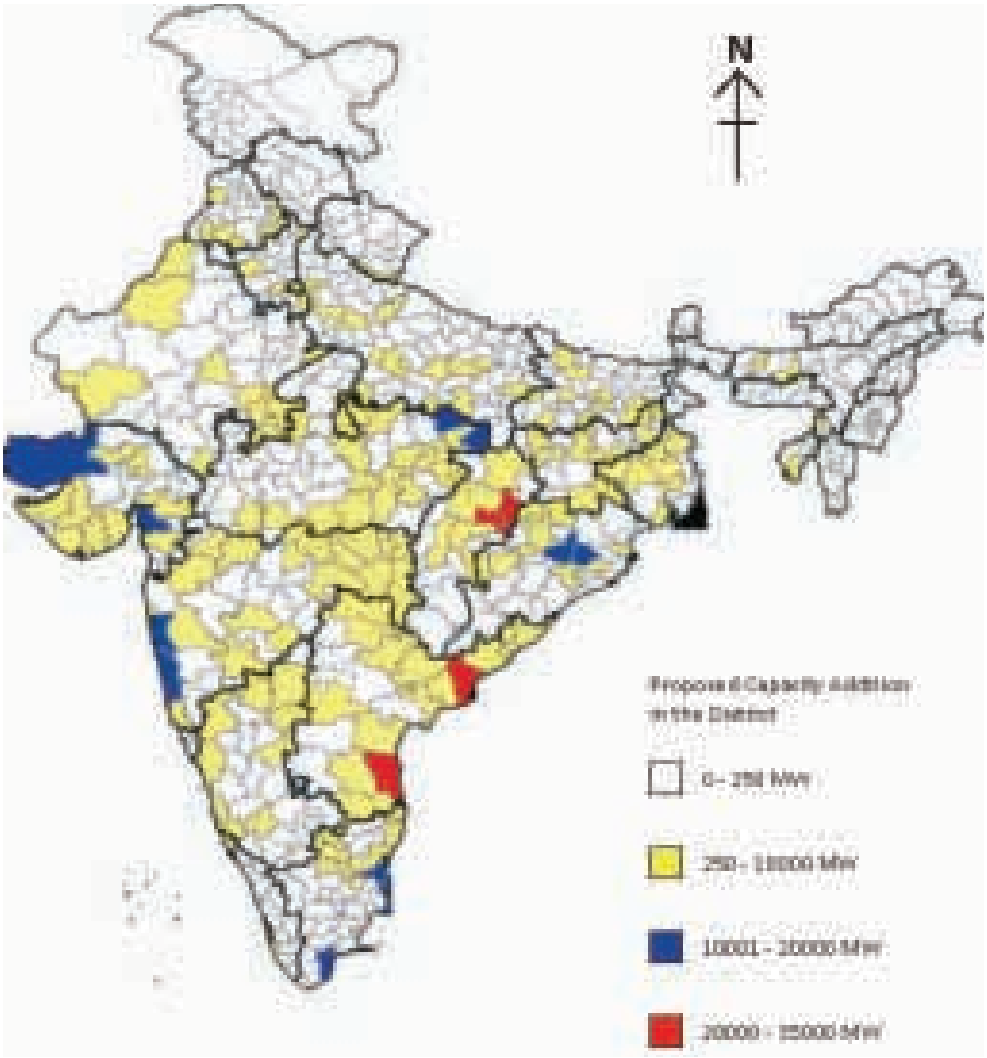


Figure 8.6: District-wise capacity addition in pipeline (Source: MoEF)[32]

31 MoEF, (IL&FS). 2009. Technical EIA guidance manual for thermal power plants.

32 Dharmadikary, S and S. Dixit. Thermal Power Plants on the Anvil: Implications and need for rationalization. Prayas Energy Group Discussion paper, 2011. Prayas, Pune, India. www.prayaspune.org/peg

8.11. Other large developments: SEZs, PCPIRs

Special Economic Zones are initiatives that are expected to attract a lot of investment. At least thirty SEZs have come up or are in the process of being set up in the coastal states. Tamil Nadu with 10 leads the group, with many of them IT parks, some textile focused, and others multi-product. The largest of the SEZs is located at Mundra, Gujarat. The table gives the number of SEZs in coastal areas compiled from various sources.

Table 8.17: SEZs in coastal areas

	State	Number of SEZs in coastal areas
1	Andhra Pradesh	5
2	Gujarat	2
3	Karnataka	1
4	Kerala	7
5	Maharashtra	4
6	Odisha	1
7	Tamil Nadu	10
8	West Bengal	5

Petrochemicals Investment Region (PCPIR): A new series of mega-projects being planned along the coast are Petroleum Chemicals and Petrochemicals Investment Regions (PCPIR). A PCPIR, according to the Government of India policy brought out in 2007 for this purpose, would be a specifically delineated region, with an area of over **250 sq km²**, planned for the establishment of manufacturing facilities for domestic and export-led production in petroleum, chemicals and petrochemicals, along with the associated services and infrastructure. Table 8.18 provides information on the statewise area to be occupied by PCPIRs.

The biggest concern about such regions is the fact that most of the petroleum is imported, and transported via pipelines to the refineries. Seaports become an important core entity of such PCPIRs. This is perhaps the reason why the five regions selected are coastal, having both ports and refineries. Those seaports will be expanded, which means that more structures will have to be created in the littoral zone, resulting in more shoreline problems. The second large concern is the requirement of land for associated infrastructure.

IIn Andhra Pradesh, the PCPIR will come up at Visakhapatnam-Kakinada-Rajahmundry within the Visakhapatnam and East Godavari Districts of Andhra Pradesh, covering an area of 603.58 sq. kms. The total industrial investment in the Andhra Pradesh PCPIR is estimated at Rs.343,000 crores including committed investments of Rs.163,890 crore. The direct and indirect employment in the PCPIR is estimated to be about 5.25 lakh and 6.73 lakh persons respectively[33]. However, according to recent news reports, not able to find any takers for the much hyped PCPIR due to various reasons, the state government is now attempting to show already existing industries in Vizag to Kakinada as part of the PCPIR and going ahead with the proposed planning to provide infrastructure worth around Rs.19,000 crore. In fact, the report says that according to official details, non-petroleum, or petrochemical entities such as pharmaceuticals, textiles and apparel are shown as part of the PCPIR, along with projected investments in the petroleum and petrochemical industry[34].

In Tamil Nadu, setting up of the first PCPIR along the coastal stretches of Cuddalore and Nagapattinam districts is to be followed by the second PCPIR in Ramanathapuram district. In Cuddalore, the petroleum refinery project under implementation by Nagarjuna Oil Corporation, a joint venture of TIDCO, will be one of the anchor units in the Cuddalore-Nagapattinam PCPIR. In the case of Ramanathapuram, an area of about 257.83 sq km along the coastal stretch of Thiruvadanai taluk, on the western side of the East Coast Road, which runs along the sea coast adjoining Palk Bay, has been identified. The total investment is expected

33 Proposed PCPIR in Andhra Pradesh. http://www.infraline.com/ong/downstream/vizagpcpir.aspx accessed 24 Aug. 12.

34 Sudhir, S.N.V.No takers for PCPIR. Deccan Chronicle, June 21, 2012. http://www.deccanchronicle.com/channels/cities/regions/visakhapatnam/no-takers-pcpir-572

to be of the order of Rs.92,160 crore[35] and it is expected that 750,200 people will be given employment opportunities[36].

In Odisha, a PCPIR is being set up in Paradip, set to be completed by 2030. It needs 70,214 acres (284.15 sq km) of land, which includes 30,397 acres (123.01 sq km) of processing area and 39,817 acres (161.14 sq km) of non-processing area. Indian Oil Corporation Ltd (IOCL) would be the anchor tenant of the project and would set up a 15 million tonnes per annum grassroot refinery cum petrochemical complex 5 km south of Paradip at a cost of Rs.29,777 crore. The refinery project was expected to be commissioned by March 2012 and stabilized 8 months later. Additional infrastructure in terms of rail connectivity was also being planned[37].

Gujarat PCPIR (GPCPIR) is a specifically delineated Investment Region planned for the establishment of production facilities for petroleum, chemicals and petrochemicals. The PCPIR located at Dahej is spread over the blocks of Vagra and Bharuch, South Gujarat. It is surrounded by the Gulf of Khambhat in the west, Narmada river & Aliyabet island to the south, villages of Vagra and Bharuch block in the east, and Bharuch-Dahej railway line in the north. The anchor tenant is ONGC Petro Additions Limited[38].

In West Bengal, the PCPIR will comprise the proposed chemical hub on the pear-shaped Nayachara Island and the adjoining industrial units in Haldia. The chemical hub, spread over 10,000 acres, is being set up by Indonesia's Salim Group, Delhi-based realty firm Unitech Ltd and Universal Success. Indian Oil Corporation (IOC) will be anchor investor at the chemical hub, for which it had inked a MoA with the West Bengal government in September 2006. To begin with, IOC had proposed to set up a 15 million tonne refinery at the chemical hub at an anticipated investment of Rs.15,000 crore[39].

Table 8.18: PCPIR

State	Location	Area
Andhra Pradesh	Visakhapatnam-Kakinada-Rajahmundry	603.58 sq km
Gujarat	Dahej	453 sq km
Odisha	Paradip	284.15 sq km
West Bengal	Nayachar-Haldia	10,000 acres (40.468 sq km)
Tamil Nadu	Cuddalore-Nagapattinam	256.83sq km
Tamil Nadu	Ramanathapuram	257.83 sq km

8.12: Summary and observations

In this chapter, the developments along the coast at the national level have been reviewed based on the data obtained during the mapping survey carried out as part of this study. The Indian mainland coastline was analysed for occupancy by the following activities: settlements, commercial activities, seawalls as protective structures, other structures in the coastal zone such as breakwaters, elevated roads, jetties etc., ports & harbours, water bodies and protected areas.

It is generally known that the Indian coastline is very densely populated. This study counted 1,262 settlements occupying 1,411.11 km or about 21% of the coastline, and about 10% of the total area falling within the 500m zone (from the high tide line) is occupied by settlements. Commercial activities such as tourism, salt production, aquaculture, sand mining, industries and institutions occupied about 10.7% of the coastline and a little less than 10% of the area in the 500 m zone. Considering that agricultural activities were excluded, the actual extent of coastal land within the 500 m zone that is used for commercial activities is likely to be much larger.

Protected areas occupy about 11.4% of the length of the coastline and waterbodies about 9%. The information on protected areas was obtained from Protected Planet[40], and there appears to be some variation between this

35 Raja Simhan, T.E. Ramanathapuram to be State's 2nd Petrochem Investment Region. Business Line. March 31, 2012. http://www.thehindubusinessline.com/todays-paper/tp-economy/article987810.ece

36 TN PCPIR to create 7.5 lakh jobs in Cuddalore region: Ministry. 11 July 2012. http://www.indianexpress.com/news/tn-pcpir-to-create-7.5-lakh-jobs-in-cuddalore-region-ministry/973083/ accessed 24 Aug. 2012.

37 PCPIR land acquisition on fast track. July 26, 2010. http://www.business-standard.com/india/news/pcpir-land-acquisitionfast-track/402471/ Accessed 24 Aug. 2012.

38 Gujarat PCPIR. http://gujaratpcpir.org/SIRs/PCPIR.pdf accessed 24 Aug. 2012.

39 Ghosal, S. High-powered committee clears West Bengal's PCPIR. The Economic Times. Feb 3, 2009. http://articles.economictimes.indiatimes.com/2009-02-03/news/27646431_1_nayachara-chemical-hub-pcpir-proposal Accessed 24 Aug. 12.

40 IUCN and UNEP-WCMC (2010), The World Database on Protected Areas (WDPA) Cambridge, UK: UNEP- WCMC. Available at:www.protectedplanet.net accessed between 1st July and 15th September 2012.

data and that reported by the MoEF. The survey and study could not separately identify CRZ 1 areas like sand dunes, mudflats, sea grass areas, turtle nesting sites heritage sites etc.

An overview of the extent of various activities on the coast

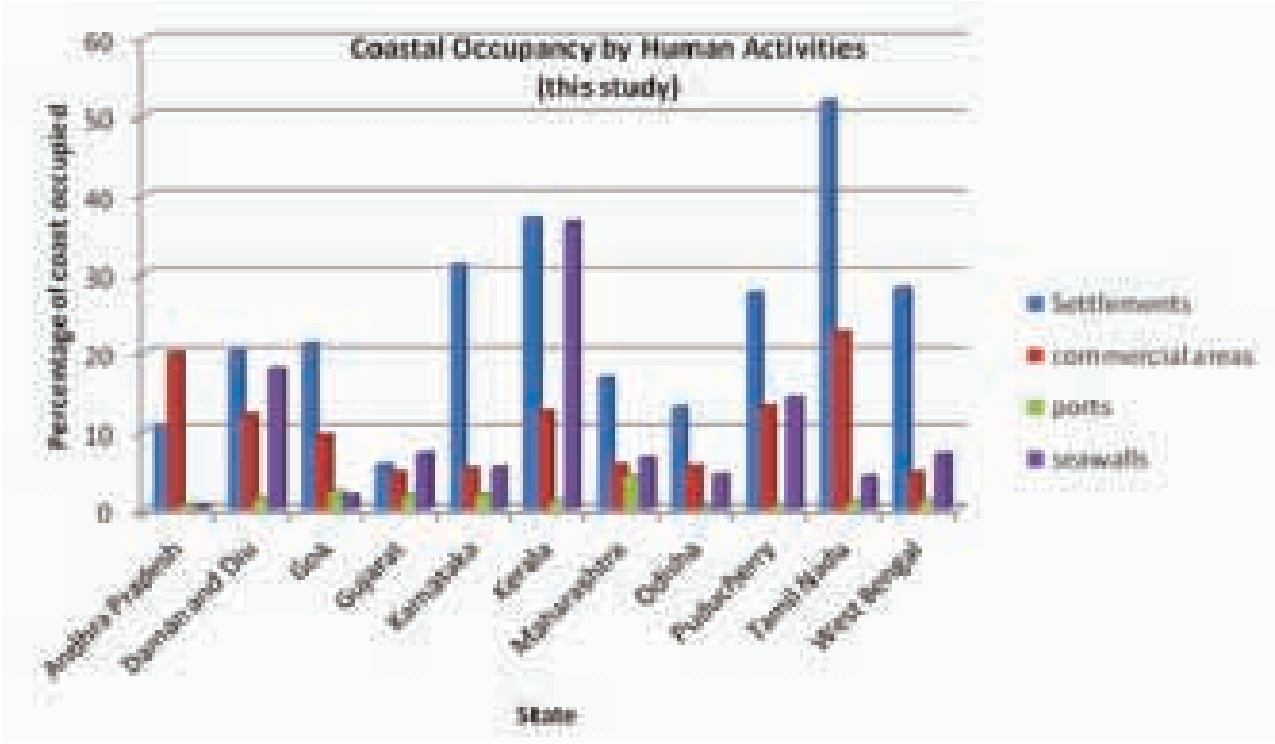


Figure 8.7: a) Coastal Occupancy by Human Activities (coastline data from this study)

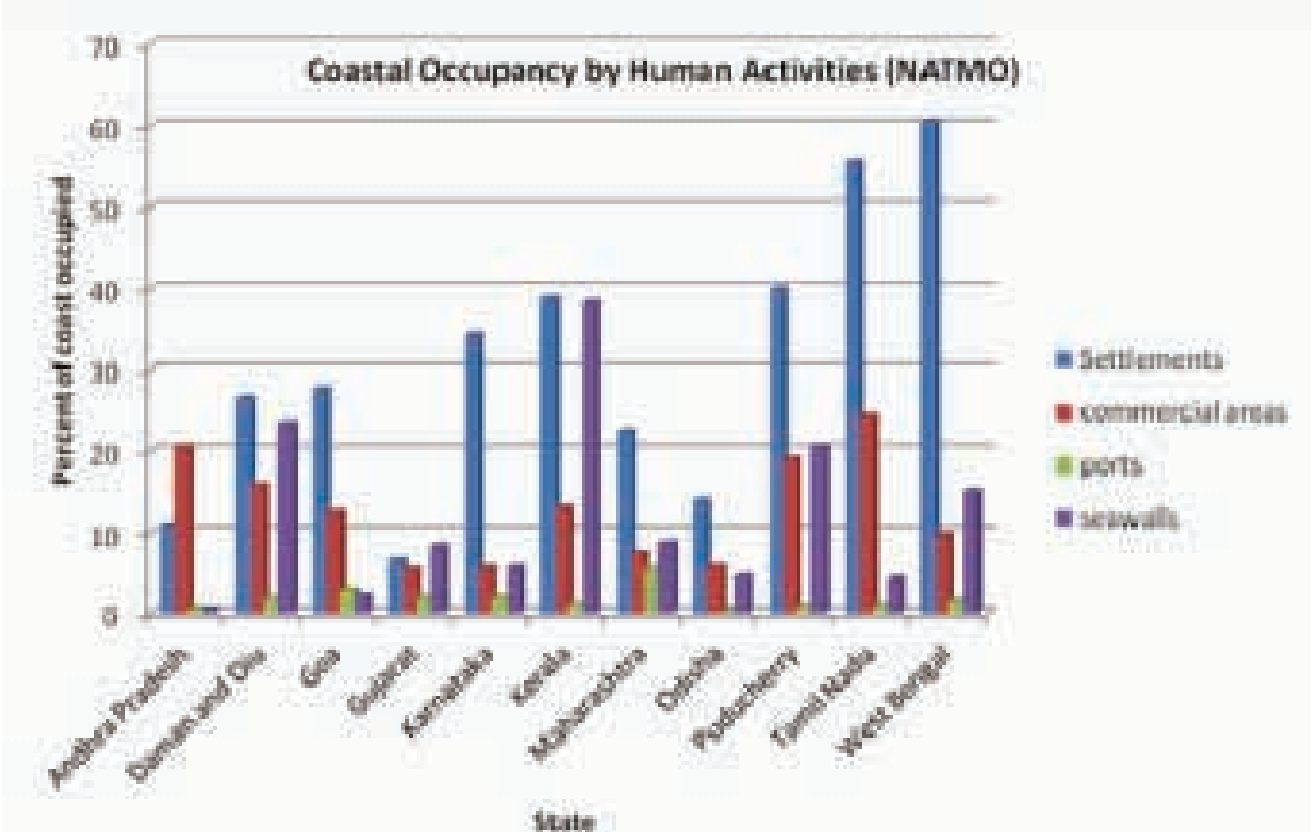


Figure 8.7: b) Coastal Occupancy by Human Activities (coastline data from NATMO)

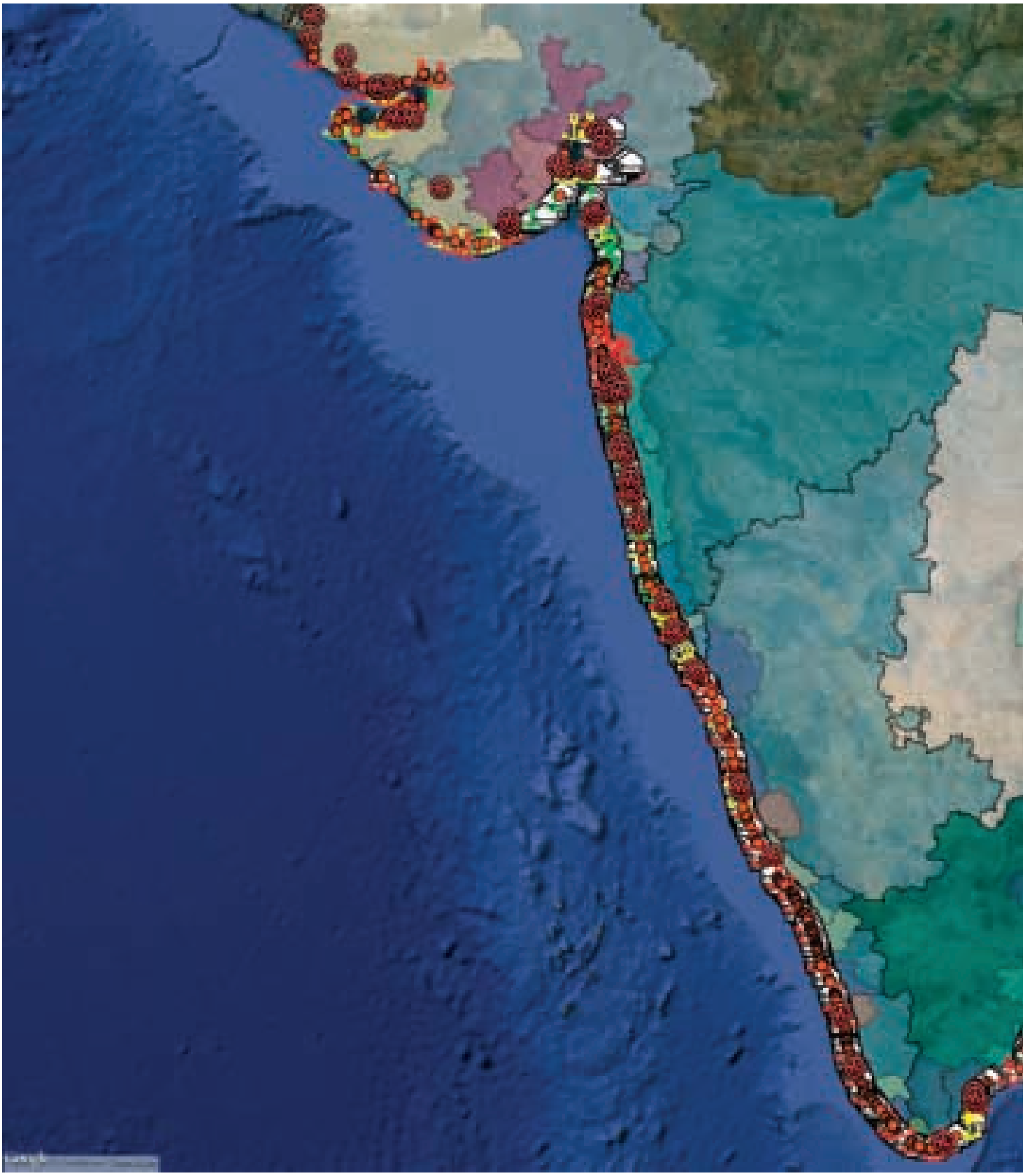
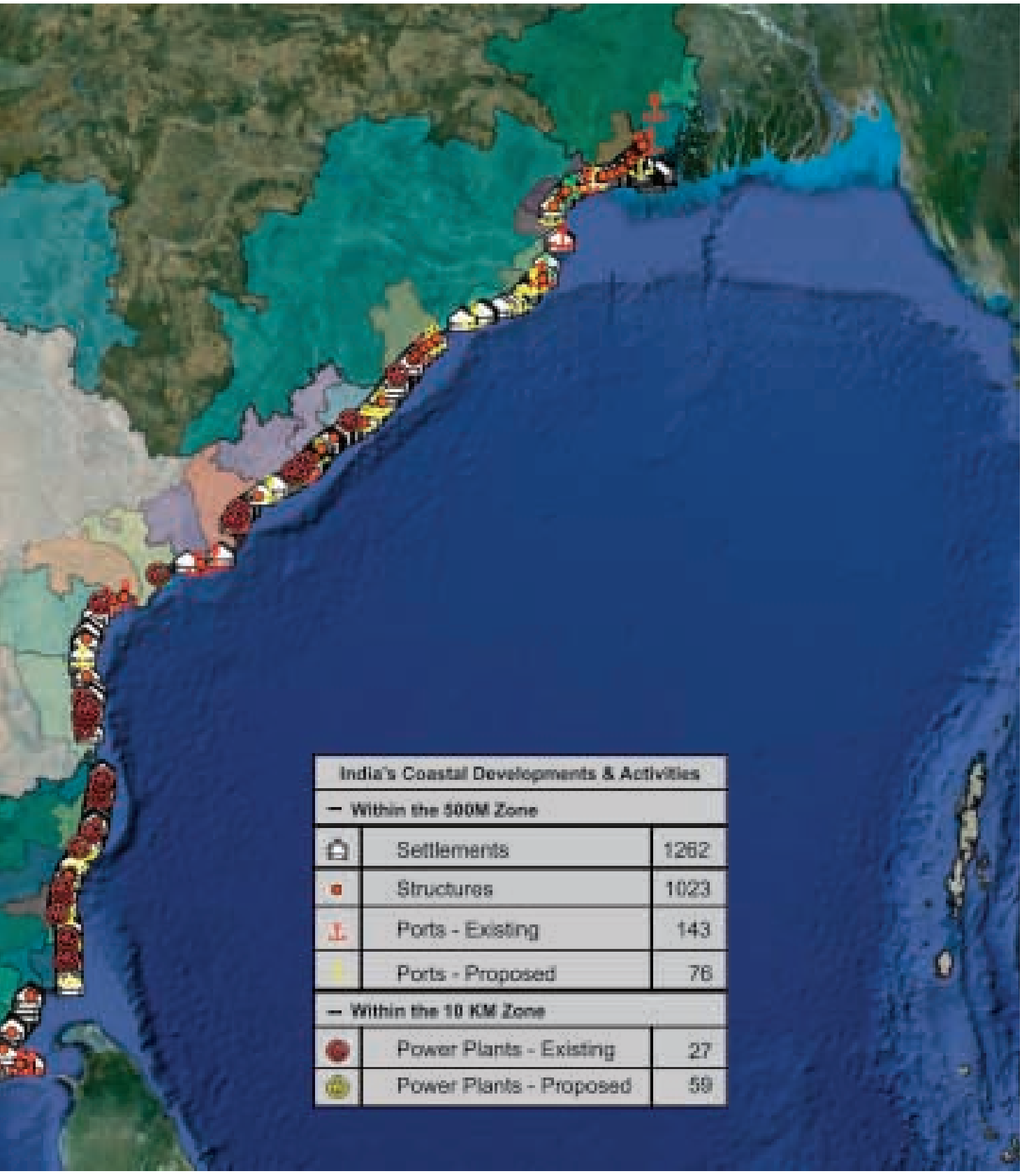


Figure 8.8: The crowded coast of India.



Concern about eroding shorelines has been on the rise in recent times. This is not surprising, as according to figures available, close to 30% of the shoreline is eroding. Symptomatic treatment by the provision of seawalls or groynes has been the standard response, ostensibly to provide immediate protection to the coastal hamlet that is under threat. This study found approximately 300 settlements blocked by seawalls. This has various repercussions, such as loss of space which affects fishing livelihoods by blocking/restricting access to the sea and other natural resources, loss of space for landing fish and parking boats, and loss of public commons used for recreation, which could also result in potential loss of income related to tourism. Ports already occupy 104 km of the coastline. Not only do their activities extend landward, but also their impacts due to associated structures such as breakwaters extend well beyond the coastline they actually occupy. The major problem created by ports is coastal erosion. This is tackled locally by coastal armouring, such as seawalls and groynes, which only extend the area of a port's impact.

A summary of the activities along the coast as measured by this study and compared with the data from NATMO is given in the table below.

Table 8.19: Summary of activities surveyed in this study

	Total Nos.	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)
Human Activities				
Settlements	1,262	1,411	21	25
Commercial Areas	1,571	714	11	13
Ports & Harbours	150	115	2	2
Sub-total:		2,275	34	40
Natural Resources				
Water bodies	594	608	9	11
Total		**2,848**	**43**	**50**

Thus it may be seen that according to this study over 34% (perhaps closer to 40% as estimated from NATMO data) of the coast is already occupied by human-related activities. But if for instance we take into account the 10 km radius impact area around ports as defined by the MoEF (as discussed in Section 8.9), then this figure changes completely and increases to about 75% of India's coastline (or about 80% according to NATMO). Similarly, the impact areas of power plants, coastal structures and all other developments and activities would reveal that a significantly larger part of the coastline is already occupied, resulting in a significant loss of biodiversity.

Of importance, it should also be noted that commercial agricultural activities are not included in the extent of coastal land that has been occupied by development activities. Given that the land area under cultivation on the coastal plains of India is estimated to be about 50%[41], the extent of land occupied by human activities along the coast is clearly quite significant.

Given that many more developments and activities are being planned along the coast in the form of ports, power plants, SEZs, PCPIRs – the number of ports and power plants is set to increase by 40% and 200% respectively if the proposed ones get implemented – not to mention the pressures of population growth and expansion of coastal settlements, it is quite evident that the coast is becoming over-crowded, apart from being directly affected by coastal structures like seawalls and groynes placed to control the extensive erosion.

All this has direct implications for the biodiversity of the coastal and marine areas, which is of special concern as it can have a direct bearing on the various coastal ecosystem services, ranging from coastal protection to nutrient cycling, food production and livelihood security of those dependent on coastal biodiversity. This is the challenge that the coast of India is facing and which this reports seeks to quantify and highlight.

41 Heitzman, James and Robert L. Worden, editors. India: A Country Study. Washington: GPO for the Library of Congress, 1995. http://countrystudies.us/india/102.htm

9. State perspectives

The 5,700 km mainland coast is shared between nine coastal states and two union territories. In this study, as mentioned earlier, the focus is only on the coast of mainland India. In this chapter we present the information that was gathered during the study and survey for each of the coastal states in the Indian peninsula, going from west to east i.e. beginning with Gujarat and ending with West Bengal. It is recommended to have read sections 2,4 and 8.1 for a better understanding of the information presented in this chapter. The information for each of the coastal states has been inventoried and is presented here as a compendium. While the information collected from all states has allowed us to obtain a larger scenario at the national level, more detailed work is required to be undertaken at the level of every state in order to derive scenarios for the coastal states. It is hoped and expected that this preliminary survey will be expanded, updated and continuously validated for the various coastal states. Any updated information for each of the coastal states will be presented and made available on the website thechallengedcoastofindia.in.

9.1. Gujarat

Introduction: The state of Gujarat is located at the northwest of the Indian peninsula and shares a border with Pakistan. The length of the coastline surveyed in this study is 1,667 km. A district-wise breakup of coastal lengths is provided in table 9.1.1 comparing them with NATMO measurements.

Table 9.1.1: Length of coastline

Length of Coastline - Gujarat		
Districts	Length (Surveyed)	Length (Natmo)
Valsad	75.8	28.0
Vadodara	14.6	
Surat	66.6	48.0
Rajkot	8.6	
Porbandar	103.0	109.0
Navsari	27.0	37.0
Kutch	349.0	340.0
Junagadh	132.0	109.0
Jamnagar	395.0	322.0
Bhavnagar	190.0	142.0
Bharuch	142.0	136.0
Anand	32.2	55.0
Amreli	105.0	46.0
Ahmedabad	26.6	36.0
Grand Total	**1667.4**	**1408.0**

In some of the districts, there appear to be significant differences between the lengths of coastline measured during our survey and those recorded by NATMO. A considerable variation is to be expected when measuring lengths of coastlines that are non-linear and irregularly shaped, when different scales are used for making the measuring. Along linear and regularly shaped alignments of the coastline, the differences are likely to be less. With the longest coastline of the country, the state covers an area of 196,024 km2 and has a population density of 308/km2 (2011 census). There are 13 coastal districts. The Gujarat coast has been broadly classified into five regions: the Rann of Kachchh, the Saurashtra coast, Gulf of Kachchh, Gulf of Khambhat and the South Gujarat coast, based on the distinct variation in the wetland/landform categories. These variations are due to climate, substrate constituents and topography. Mangrove forests occupy creeks and tributaries that crisscross the coast. The main rivers flowing in Gujarat are Sabarmathi, Mahi, Narmada and Tapti. The Tropic of Cancer passes through the northern border of Gujarat. 28 per cent of the coast has sandy beaches, 21 per cent is rocky, 39 per cent is mudflats, and 22 per cent is marshy, according to NHO data. In 2004, the length of the coastline affected by erosion was 36 km, about 3 per cent; latest estimates give the length affected by erosion as 155 km; 12 per cent, a fourfold increase in about seven years. The extent of coastline protected is 22 km (see Table 8.7). However, the mapping details from the current study give the extent of seawalls as 118 km.

Gujarat's coast is also vulnerable to earthquakes and cyclones according to the Building Materials Technology Promotion Council's (BMTPC) Vulnerability Atlas[1] for the state. The Kachchh region is partly in Zone IV and Zone V for earthquake vulnerability (very high and high damage risk zone). In 2001, an earthquake of magnitude 7.7 on the Richter scale struck the region, killing about 20,000 people (Bhuj earthquake)[2]. Most of the coast is also on the very high and high damage risk zone for wind and cyclones.

The Government of Gujarat has constituted "Gujarat Coastal Area Development Board" (GCAD) to develop the marine/coastal resources along the 1,600 km coastline of Gujarat[3]; the Gujarat Maritime Board (GMB) along with the GCAD board will primarily look into tourism, forest & environment, fisheries development, industrial development and natural calamity management, etc.

ICZMP Gujarat: The state is also part of the National ICZM Project funded by the World Bank. Gujarat Ecology Commission[4] is the State Project Management Unit responsible for building long-term institutional sustainability, aimed at helping the coastal zone management of the Department of Forest & Environment, as per the state's medium-term capacity building plan. A project called "Green Action for National Dandi Heritage Initiative (GANDHI for Dandi)" for the overall development and conservation of the environment of Dandi and its surrounding villages, based on Gandhian teachings on environmental conservation and village development, is being executed by the SPMU. Mangrove restoration and coral transplantation are also part of activities to be carried out.

Ecology and biodiversity: Natural ecosystems of Gujarat range from wetlands and grasslands to deciduous forests and deserts. Some of the unique ecosystems include Flamingo City (between Khadir and Pachham islands in the Great Rann of Kachchh), which is the largest breeding ground of flamingos, the Great Rann of Kachchh (GRK), and the Little Rann of Kachchh (LRK), spread over 25,000 km^2. The seasonal inundation by rain water and diurnal inundation of the western half of the GRK by sea water, coupled with a high residual salinity level, provides a rare and unique type of ecosystem. There is a wild ass sanctuary in the LRK. The barren Bhal region is known for its indigenous varieties of Bhalia and Rata wheat[5]. The Banas, Sabarmati, Mahi, Narmada and Tapi are major rivers draining into the Gulf of Khambhat, while the rivers Bhader, Ojat and Shetrunji are those of Kathiawar peninsula draining into the Arabian Sea. There are a few small seasonal rivers draining into the Gulf of Kachchh. The wetlands of the state are major wintering areas for cranes, pelicans, flamingos, ducks and shore birds. The only population of Dugong on the west coast of India is present in the Gulf of Kachchh region[6]. A number of Marine protected areas and coastal water bodies are present in the state and have been mapped as given in the following tables.

1 Vulnerability Atlas of India (First Revision - 2006).

2 Bhuj Earthquake of January 2001. http://www.imd.gov.in/section/seismo/static/bhuj_equake.htm accessed 20 Aug. 2012.

3 Gujarat Maritime Board. Coastal Area Development and Ro-Ro services http://www.gmbports.org/showpage.aspx?contentid=1449 Accessed 23 Aug. 2012.

4 Gujarat ICZM and GEC. http://www.geciczmp.com/about-us.aspx

5 Jasrai, Dr. Biodiversity of India----flora form. http://www.vigyanprasar.gov.in/radioserials/indian_flora.pdf accessed 24 Aug. 12.

6 Stanley, O.D. Wetland ecosystems and coastal habitat diversity in Gujarat, India. Journal of Coastal Development , Volume-7, Number 2, February 2004: 49-64.

Table 9.1.2: List of wetlands[7]

Wetlands of Gujarat							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Ahmedabad	18	5	-	-	-	24	21
Amreli	2	1	-	3	-	22	21
Anand	7	8	1	-	-	19	33
Banaskantha	-	-	-	-	-	9	25
Bharuch	26	-	-	-	-	42	63
Bhavnagar	16	13	7	11	-	44	30
Daman & Diu	7		3	7	-	1	9
Jamnagar	116	40	10	12	50	73	176
Junagadh	11	4	5	16	-	22	19
Kutch	459	95	5	18	-	55	653
Navsari	44	4	1	3	-	22	32
Patan	-	-	-	-	-	2	34
Porbandar	-	-	8	3	-	1	-
Rajkot	12	2	-	-	-	32	29
Surat	39	7	-	1	-	19	34
Surendranagar	-	-	-	-	-	-	29
Vadodara	1	9	-	-	-	-	5
Valsad	16	1	-	3	-	10	17
Grand Total	**774**	**189**	**40**	**77**	**50**	**397**	**1230**

Table 9.1.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of Gujarat							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (Natmo)	(%) Area Occupied (NATMO)
Ahmedabad	-	-	-	-	-	-	-
Amreli	-	-	-	-	-	-	-
Anand	-	-	-	-	-	-	-
Bharuch	-	-	-	-	-	-	-
Bhavnagar	-	-	-	-	-	-	-
Jamnagar	2	138	69	34.9	34.9	42.9	42.9
Junagadh	-	-	-	-	-	-	-
Kutch	-	-	-	-	-	-	-
Navsari	-	-	-	-	-	-	-
Porbandar	-	-	-	-	-	-	-
Rajkot	-	-	-	-	-	-	-
Surat	-	-	-	-	-	-	-
Vadodara	-	-	-	-	-	-	-
Valsad	-	-	-	-	-	-	-
Grand Total	2	138	69	8.3	8.3	9.8	9.8

7 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Table 9.1.4: Water bodies surveyed in this study

Water Bodies of Gujarat								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ahmedabad	-	-	-	-	-	-	-	-
Amreli	3	-	3.4	1.9	4.6	5.2	7.4	8.3
Anand	-	-	-	-	-	-	-	-
Bharuch	-	-	-	-	-	-	-	-
Jamnagar	5	3	6.0	1.6	1.5	0.8	1.9	1.0
Junagadh	17	1	11.9	2.9	6.6	3.2	11.0	5.3
Navsari	-	2	4.3	6.1	15.9	45.4	11.6	33.1
Porbandar	4	-	5.1	1.5	5.0	3.0	4.7	2.8
Rajkot	-	-	-	-	-	-	-	-
Surat	1	-	1.0	0.4	1.5	1.3	2.1	1.8
Vadodara	-	-	-	-	-	-	-	-
Valsad	16	-	15.1	3.5	20.0	9.2	54.0	25.0
Bhavnagar	4	1	6.5	2.0	3.4	2.2	4.6	2.9
Kachchh	21	-	32.1	9.2	8.1	4.7	9.4	5.4
Grand Total	**71**	**7**	**85.5**	**29.2**	**4.6**	**3.2**	**6.1**	**4.1**

The Gulf of Kachchh is a shallow water body with depth extending from 60 m at the mouth to less than 20 m at the head of the Gulf. The Marine National Park and Marine Sanctuary are situated along the southern shore of the Gulf from Okha (22º 30'N, 69º 00'E) and extend eastwards to the vicinity of Khijadia (22º 30'N, 70º 40'E). In 1980, an area of 270 km^2 from Okha to Jodiya was declared as a Marine Sanctuary. Later, in 1982, a core area of 110 km^2 was declared Marine National Park under the provisions of the Wildlife (Protection) Act, 1972, of India. It comes under the IUCN Category II (national park). The park includes 42 islands and a complex of fringing reefs backed by mudflats, sandflats, coastal salt marsh, mangrove forests, and sandy and rocky beaches which support a great diversity of fauna and flora. The area also has many islands fringed with corals and mangroves which provide disturbance-free habitats for many species of nesting birds. Besides these islands, there are a number of wave-cuts, eroded shallow banks like the Pirotan, Deda, Donna, Sankhodhar Beyt, Paga and Boria, which accounts for coral islands[8]. The area was also declared as an eco-sensitive zone in 2012, with extensive prohibitions on the discharge of effluents and setting up of industries, among other things[9].

More than 800 species are found in the Gulf of Kachchh. These include 32 hard (Scleractinia) and 12 soft (Alcyonaria) corals, 150-200 species of fishes, more than 100 species of algae, plus a great diversity of sponges, molluscs, worms and echinoderms. New species have also been discovered: for example, in 2008 scientists from the Gujarat Institute of Desert Ecology (GUIDE) found 92 species of sea creatures, previously unknown, to be living in the arid northern coast of the Gulf of Kachchh that stretches roughly from Mundra to Jhakhou. The organisms found included gastropods, bivalves, crustaceans, polychaetes, shrimps and lobsters[10]. Apte et al. (2010)[11] reported 21 new records of

8 Gulf of Kachchh. Ecologically Important Areas of Gujarat Coast. http://www.annauniv.edu/iom/iomour/Gulf%20of%20Karchch.htm accessed 24 Aug. 12.

9 MoEF, Marine National Park and Marine Sanctuary Eco-sensitive Zone. 29 February 2012. http://moef.nic.in/downloads/public-information/notif-marine-national-park-02032012.pdf

10 Kumar, S. 92 unknown marine species discovered in northern Gulf of Kutch. http://www.expressindia.com/latest-news/92-unknown-marine-species-discovered-in-northern-Gulf-of-Kutch/306869/ Accessed 8 May 2008.

11 Apte, D.A., Vishal Bhave and Dishant Parasharya (2010) An Annotated and Illustrated Checklist of the Opisthobranch Fauna of Gulf of Kutch, Gujarat, India, with 20 new records for Gujarat and 14 new records for India. Part 1. Journal of Bombay Natural History Society, 107 (1), 14-23.

Opisthobranchs in Gujarat, with 13 new records to India from Gulf of Kachchh region. Marine turtles and other reptiles visit regularly and there are over 200 species of migratory and resident bird species. The rare and endangered marine mammal, the Dugong, is found here, and three species of dolphins also visit the area. 13 species of sea mammals have been recorded, but only small mammals visit the shallow waters of the MPA to feed. The western part of the MPA supports 80% of the marine mammals that visit here[12].

Gulf of Khambat is described as a south-to-north penetration of the Arabian Sea on the western shelf of India between the Saurashtra peninsula and mainland Gujarat. Its north-south length is 115 km. It covers an extent of about 3,120 km^2, mainly of mudflats with some rocky (sandstone) inter-tidal area and a volume of 62,400 million m^3. Rocky beaches are common from Mahuva to Gopnath, reducing in numbers towards Ghogha and Bhavnagar. A few sandy patches are also seen intermittently. The gulf is intercepted by several sea inlets and creeks. The ecosystems of the gulf comprising mangroves, estuaries, creeks and vast intertidal mud flats are known to have rich biodiversity and a number of endemic flora and fauna. Rapid development and heavy industrialization on the coast has resulted in the degradation of the environment, especially geomorphological changes that could be linked to development activities such as dams and destruction of mangroves and decline in biodiversity[13].

Table 9.1.5: Land use/land cover in the Gulf of Khambat[14]

Classification	Area (km^2)	Classification	Area (km^2)
Aquaculture	1.47	Salt pan	132.52
Barren land	888.91	Sand dune	14.48
Salt affected land	668.87	Sandy beach	8.36
Industries	33.11	Built-up land	391.84
Island	0.72	Swampy land	50.46
Levee	25.24	Waterlogged/marshy land	31.10
Mangrove	53.95	Reserved forest	2.76
Mangrove mixed swamp	67.16	Reservoir/ tank	57.37
Point bar	77.28	River/ canal	308.87
Raised mud	1,462.87	River mouth bar	19.89
Recent mud	1,124.86	Other land	9,234.81
Rocky shore	5.20	**Total**	**14,662.08**

The Gulf of Khambat supports a vast intertidal expanse due to the high tidal range. Mangroves have been reduced to open scrubby forms with simplified zonation. Reasons for this include natural causes as well as destruction for salt works, construction of jetties, and damage from oil pollution. Afforestation programmes have been taken up in some areas. Fishing is a major activity.

The world's largest ship-breaking yard is located at Alang-Sosiya complex in Bhavnagar district. Availability of high tidal amplitude (up to 12m), silt-free beach, quick drying of seabed during the ebb tide, low cost labour and ready market for iron scrap have been the cause of the growth of Alang as a ship-breaking site. The result is that there has been a growth of a number of other industries such as re-rolling, oxygen producing and LPG bottling plants in the region. The area is also highly polluted[15].

12 Singh, H.S. Sea mammals in marine protected area in the Gulf of Kachchh, Gujarat State, India. Indian J. Marine Sciences.32 (3) 2003: 258-262.

13 ICMAM, 2002. Critical Habitat Information System for the Gulf of Khambat, Gujarat. Department of Ocean Development, Government of India.

14 Ibid.

15 Ibid.

Coastal settlements: This study has mapped the space occupied by coastal settlements as given in the table below.

Table 9.1.6: Settlements surveyed in this study

Settlements of Gujarat							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Navsari	9	8.9	2.2	33.1	16.6	24.2	12.1
Valsad	29	24.0	6.2	31.7	16.2	85.8	43.9
Amreli	9	8.6	8.0	8.2	15.3	18.7	35.0
Bharuch	26	18.3	9.9	12.9	13.9	13.5	14.6
Junagadh	8	6.9	3.8	5.2	5.7	6.3	6.9
Porbandar	1	1.2	0.2	1.1	0.4	1.1	0.4
Surat	3	4.6	2.5	6.9	7.6	9.6	10.5
Vadodara	3	3.4	1.2	23.6	17.0	-	-
Rajkot	-	-	-	-	-	-	-
Jamnagar	-	-	-	-	-	-	-
Ahmedabad	-	-	-	-	-	-	-
Anand	-	-	-	-	-	-	-
Kachchh	-	-	-	-	-	-	-
Bhavnagar	17	16.0	5.0	8.4	5.2	11.2	7.0
Grand Total	**105**	**91.8**	**39.0**	**5.5**	**4.7**	**6.5**	**5.5**

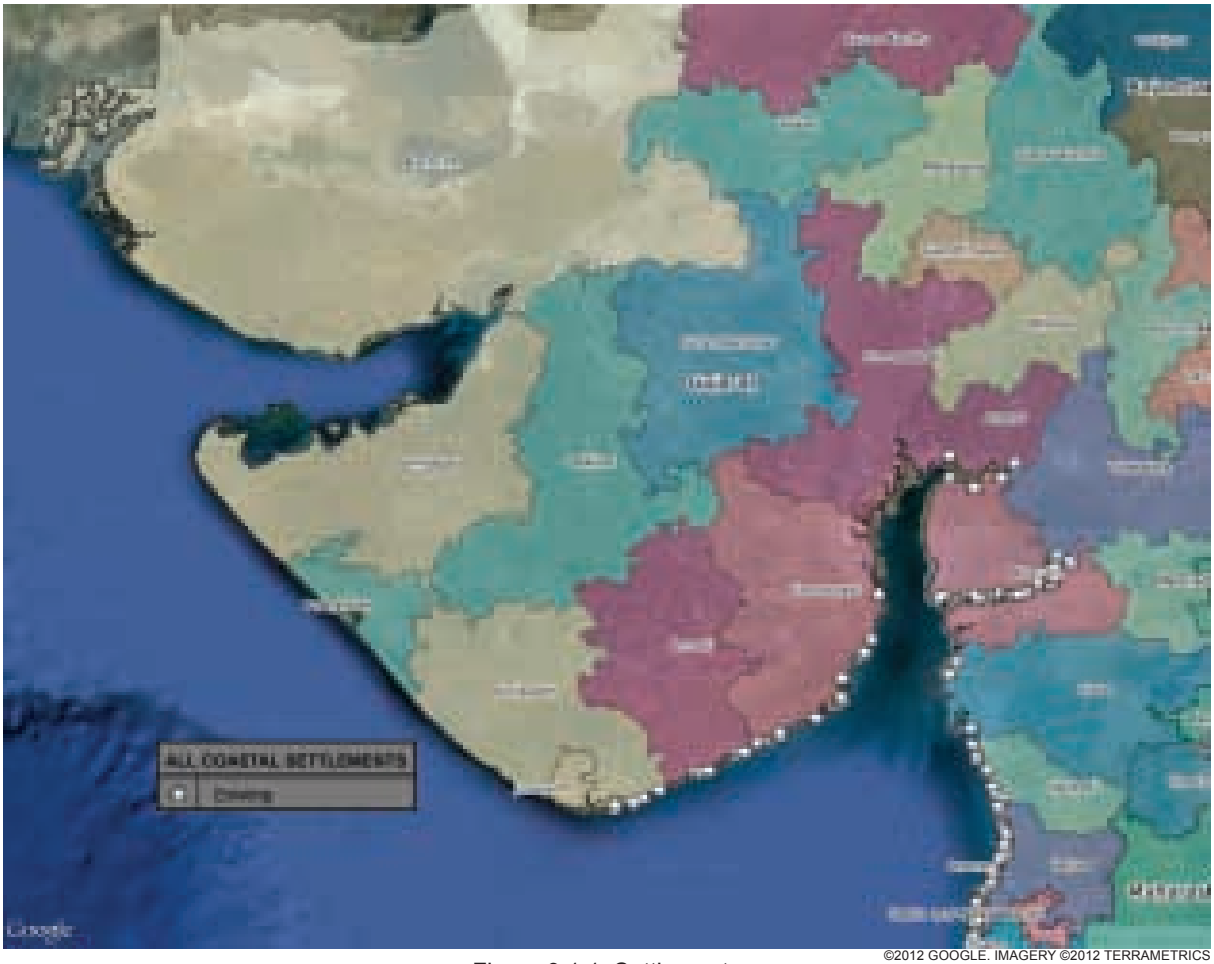


Figure 9.1.1: Settlements

A summary of the district-wise distribution of the population of the marine fishing communities of Gujarat is given in the table.

Table 9.1.7: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
Kachchh	68	3,505	3,505	683	20,982
Rajkot	4	1,831	1,831	1,335	7,847
Jamnagar	24	8,658	8,611	905	45,252
Porbandar	5	6,420	5,588	995	30,937
Junagadh	27	15,613	15,284	2,175	92,076
Amreli	6	3,092	3,092	833	24,623
Bhavnagar	26	1,503	1,290	232	7,765
Anand	1	263	263	172	1,378
Bharuch	23	2,591	2,579	1,568	13,173
Navsari	18	5,832	4,894	3,022	27,872
Valsad	24	9,772	9,471	2,628	49,187
Surat	21	3,151	3,061	1,236	15,089
Gujarat	247	62,231	59,469	15,784	336,181

Fishing: Gujarat, with about 20% (1,600 km) of the country's coastline, 33% of the continental shelf area (164,000 km^2) and over 200,000 km^2 of EEZ, ranks second among the maritime states in marine fish production. It has the largest area of coastal wetlands of all the maritime states of India. It has two gulfs – Gulf of Kachchh and Gulf of Khambat – out of the three gulfs in the country. Its continental shelf occupies 1,65,000 km^2, being 35% of the Indian continental shelf, and the Exclusive Economic Zone is about 200,000 km^2 (10% of Indian EEZ).

The estimated marine fish production from Gujarat in 2010 was 506,000 tonnes, showing a marginal decrease of 0.3% from the previous year. Gear-wise landings indicate that mechanised multi-day trawlers (MDTN) contributed 61% of the total fish landings, followed by mechanised dolnetters at 23%. Outboard gillnets contributed 7%, single-day trawlers and mechanised gillnets 4% each, and other gears 1% of the total landings[16]. A conspicuous change has been noticed in the resource composition over the years, with quality fishes like pomfrets, larger sciaenids, threadfins and penaeid prawns being replaced by low value fishes such as ribbonfishes, threadfin breams, carangids, non-penaeid prawns and smaller crabs[17].

PHOTOS: V.V.VIVEKANANDAN

Figure 9.1.2: a) After fishing b) catch is brought back to land in donkey carts, c) sorted, d) hung out to dry

16 CMFRI Annual Report 2010-11.

17 Mohanraj, G and K V Somasekharan Nair, P K Asokan, and Shubhadeep Ghosh, (2009). Status of marine fisheries in Gujarat with strategies for sustainable and responsible fisheries. Asian Fisheries Science, 22 (1). pp. 285-296.

Commercial Areas: In addition to coastal settlements, there are 'commercial spaces' which include resorts and hotels, salt pans and other activities in the intertidal zone as well as in the CRZ (up to 500 m landward).

Table 9.1.8: Commercial areas surveyed in this study

Commercial Areas of Gujarat							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (NATMO) (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Amreli	7	22.7	3.8	21.7	7.3	49.4	16.6
Bharuch	7	19.4	55.7	13.6	78.4	14.2	81.9
Jamnagar	7	3.9	1.2	1.0	0.6	1.2	0.8
Junagadh	26	13.6	2.7	10.3	4.2	12.5	5.0
Navsari	5	2.1	3.8	7.8	27.9	5.7	20.3
Porbandar	11	6.0	1.3	5.8	2.5	5.5	2.4
Surat	2	4.2	9.8	6.3	29.3	8.8	40.6
Valsad	7	3.0	2.4	3.9	6.4	10.6	17.3
Ahmedabad	-	-	-	-	-	-	-
Anand	-	-	-	-	-	-	-
Vadodara	-	-	-	-	-	-	-
Rajkot	-	-	-	-	-	-	-
Kachchh	4	1.6	0.4	0.5	0.2	0.5	0.2
Bhavnagar	-	-	-	-	-	-	-
Grand Total	**76**	**76.4**	**81.1**	**4.6**	**9.7**	**5.4**	**11.5**

Salt: India is the third largest salt producing country in the world, and Gujarat accounts for 77% of the total salt produced in India. The salt industry is labour intensive. It is estimated that an average of 109,000 labourers are employed in this industry. In the state, salt is produced along the coast of Gujarat in Jamnagar, Mithapur, Jhakhar, Chira, Bhavnagar, Rajula, Dahej, Gandhidham, Kandla, Maliya, and Lavanpur[18]. In the Little Rann of Kachchh, there is a lot of underground saline water trapped by salt pans. It is seasonal work from September to March. In the case of sea salt, the migration of workers is towards the coast. The work is back-breaking and there is no access to protective wear or medical help when required[19]. A new problem is the pollution due to industries: thousands of acres of salt pans in Gandhidham have turned black and barren due to dust and soot carried from polluting units located nearby[20].

18 Salt Industry in India. http://saltcomindia.gov.in/industry_india.html?tp=Salt accessed 24 Aug. 12.

19 Ibid.

20 Pollution threatens salt production in Gandhidham. Video uploaded by NDTV on 2 Nov., 2007. http://www.youtube.com/watch?v=ZIg-PANWjj8

Coastal structures: The major structures in the littoral zone are pipelines, seawalls, piers, groynes, harbour, breakwater, elevated road, jetty and a dock. The seawalls, groynes and breakwaters are mostly rubble mounded or RCC structures. A summary of the extent of structures mapped by this study is given in the table below, followed by the table on seawalls as mapped in this study.

Table 9.1.9: Structures surveyed in this study

Structures of Gujarat									
Districts	Breakwater	Bridge	Detached breakwater	Dock	Elevated road	Jetty	Pier	Pipeline	Grand Total
Amedabad	-	-	-	-	1	1	-	-	2
Amreli	-	-	-	-	1	3	4	-	8
Anand	-	-	-	-	-	-	-	1	1
Bharuch	-	-	-	-	-	5	-	-	5
Bhavnagar	1	-	-	-	-	-	-	1	2
Jamnagar	8	1	-	3	5	5	36	-	58
Junagadh	7	1	2	-	2	4	6	-	22
Kachchh	9	-	-	-	1	-	8	2	20
Porbandar	2	1	-	-	1	1	8	2	15
Surat	2	-	-	-	1	2	1	-	6
Vadodara	-	-	-	-	-	-	2	-	2
Total Nos.	**29**	**3**	**2**	**3**	**12**	**21**	**65**	**6**	**141**
Total Length of Structures (km)	**18.3**	**1.4**	**1.8**	**1.9**	**18.6**	**29.2**	**15.7**	**1.6**	**88.5**

Table 9.1.10: Seawalls and groynes surveyed in this study

Seawalls &Groynes of Gujarat						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Ahmedabad	-	-	-	-	-	-
Amreli	10	13.4	12.7	29.0	13	0.6
Anand	2	1.4	4.3	2.5	-	-
Bharuch	3	1.3	0.9	0.9	3	0.6
Bhavnagar	-	-	-	-	-	-
Jamnagar	42	49.1	12.4	15.2	1	0.3
Junagadh	12	10.3	7.8	9.5	2	0.7
Kachchh	17	29.9	8.6	8.8	2	0.3
Navsari	-	-	-	-	-	-
Porbandar	18	7.0	6.8	6.4	2	0.2
Rajkot	-	-	-	-	-	-
Surat	4	5.6	8.4	11.6	2	0.3
Vadodara	-	-	-	-	-	-
Valsad	-	-	-	-	-	-
Grand Total	**108**	**117.9**	**7.1**	**8.4**	**25**	**3.0**

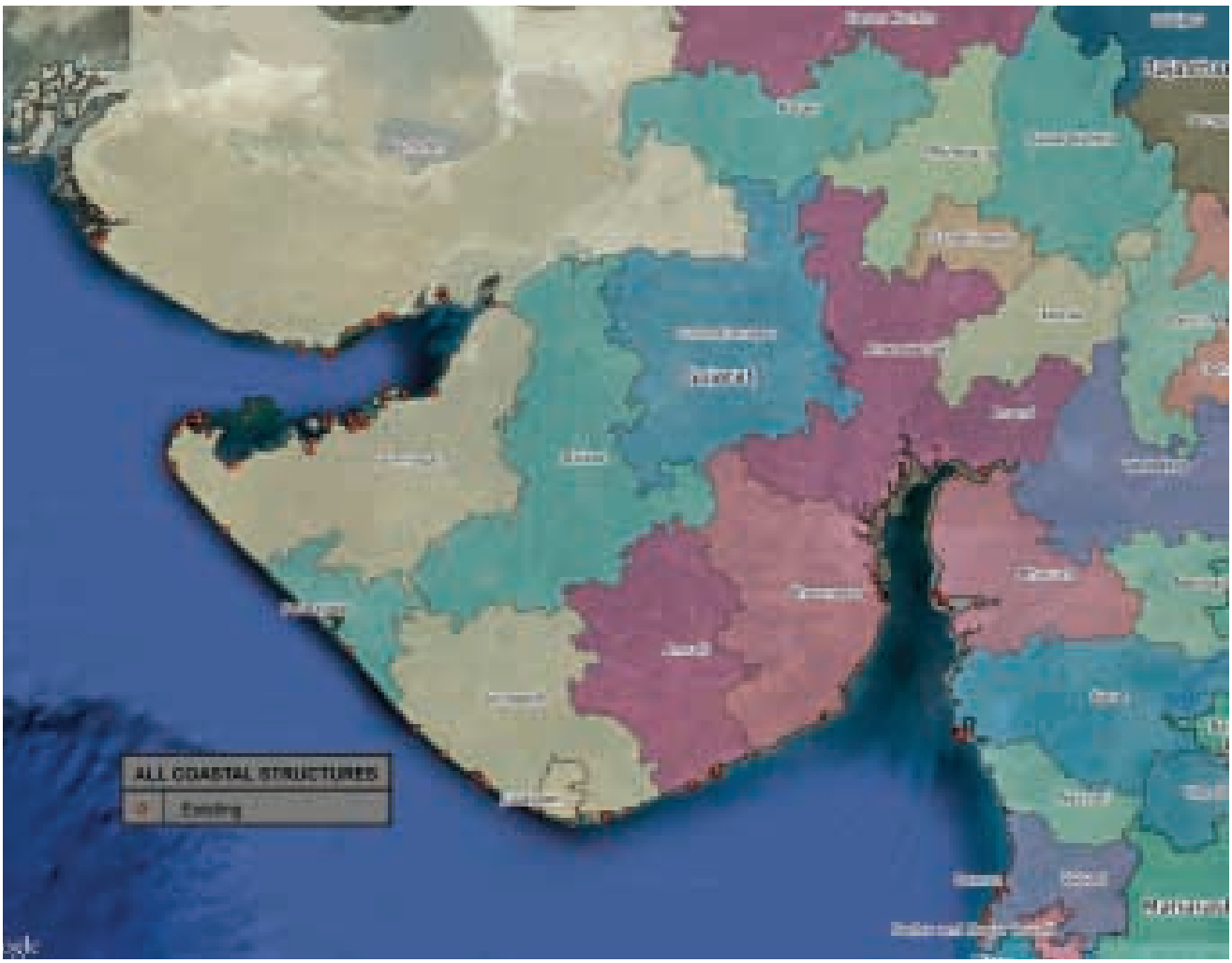


Figure 9.1.3: Structures

Ports and harbours: Gujarat with its long coastline has the second largest number of ports and harbours after the state of Maharashtra, Gujarat has one major port at Kandla[21], situated in the Kandla Creek and 90 kms from the mouth of the Gulf of Kachchh. It is a protected natural harbour. Kandla is a multi-product port. It has 12 dry cargo berths with a total length of 2.6 km in a straight line and 6 oil berths for handling of POL and chemicals. The single buoy moorings in Vadinar can handle Very Large Crude Carriers (VLCC) with a pumping capacity of 5,000 tonnes per hour.

The State's Port Policy Statement of December 1995 spelled out an explicit strategy of port-led development, including the creation of 10 completely new world-class ports in which private-sector participation played a dominant role. This led to the expansion of many notified minor ports. Thus, in addition to the major port at Kandla, there are 47 non-major ports. Gujarat Maritime Board was created in 1982 under the Gujarat Maritime Board Act, 1981, to manage, control and administer the 41 minor ports of Gujarat. During the year 2011-12, ports in Gujarat handled about 259 million tonnes of cargo, compared to 231 million tonnes handled during the previous year, making a 12% increase in the traffic handled. Capacity of 39 MT was added during the current year 2011-12, augmenting the capacity of Gujarat ports to 323 MT.

The port-led development in Gujarat is described by the GMB under six topics. These include:

Greenfield ports: 11 greenfield sites to be developed as all-weather direct berthing ports. These capital-intensive port projects are being developed under BOOT policy (Build Own Operate Transfer) and will be transferred back to GMB after completion of 30 years BOOT period. Developed sites include: Pipavav Port, Mundra Port (now Mundra Port SEZ Ltd), Dahej (petroleum) and Hazira (LNG).

Those in the pipeline include Dholera, Positra, Maroli, Chhara, Vansi-Borli, Mithivirdi and Bedi. In addition to the identified 11 Greenfield port sites, GoG/GMB has also identified new sites viz. Mahuva, Khambhat, Dahej, Sutrapada and Modhawa to be developed as deep-draught ports.

21 Kandla Port Trust. http://kandlaport.gov.in

Ship recycling: Alang, the best known site for ship recycling, is on the western coast of Gulf of Cambay, near Alang – Sosiya village. It is covered under the extended port limit of Talaja port, primarily a fishing port.

The other activities under port-led development include **Ro-Ro ferry services**, **ship building** (six shipbuilding yards in operation, three under construction, eight under process of approval, and thirteen more envisaged), **marine tourism** (development of marinas, flotels, cruise lines and beach tourism) and bunkering (prominent locations are Mundra, Kandla and Dahej).

The number of ports and space occupied by them along the shoreline in Gujarat as surveyed during this project is given in the table below.

Table 9.1.11: Ports surveyed in this study

Ports & Harbours of Gujarat							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ahmedabad	-	-	-	-	-	-	-
Amreli	2	2.3	1.7	2.2	3.2	5.0	7.2
Anand	-	-	-	-	-	-	-
Bharuch	2	1.5	0.5	1.1	0.7	1.1	0.8
Bhavnagar	4	0.9	0.8	0.5	0.8	0.7	1.1
Jamnagar	8	4.1	1.5	1.1	0.8	1.3	1.0
Junagadh	4	2.8	0.3	2.1	0.5	2.6	0.6
Kachchh	3	5.5	4.1	1.6	2.3	1.6	2.4
Navsari	2	1.0	0.6	3.5	4.4	2.6	3.2
Porbandar	1	0.6	0.2	0.6	0.5	0.6	0.4
Rajkot	-	-	-	-	-	-	-
Surat	2	10.2	3.2	15.3	9.6	21.2	13.3
Vadodara	-	-	-	-	-	-	-
Valsad	4	0.7	0.1	1.0	0.1	2.6	0.4
Grand Total	**32**	**29.7**	**13.0**	**1.8**	**1.6**	**2.1**	**1.8**

Table 9.1.12: Proposed ports

Proposed ports		
No. of ports		
State	**District**	**Total**
Gujarat		
	Ahmedabad	1
	Amreli	1
	Anand	1
	Bharuch	1
	Bhavnagar	1
	Jamnagar	2
	Jamnagar	1
	Junagadh	1
	Junagadh	1
	Kachchh	4
	Navsari	1
	Surat	1
	Valsad	2
Total		**18**

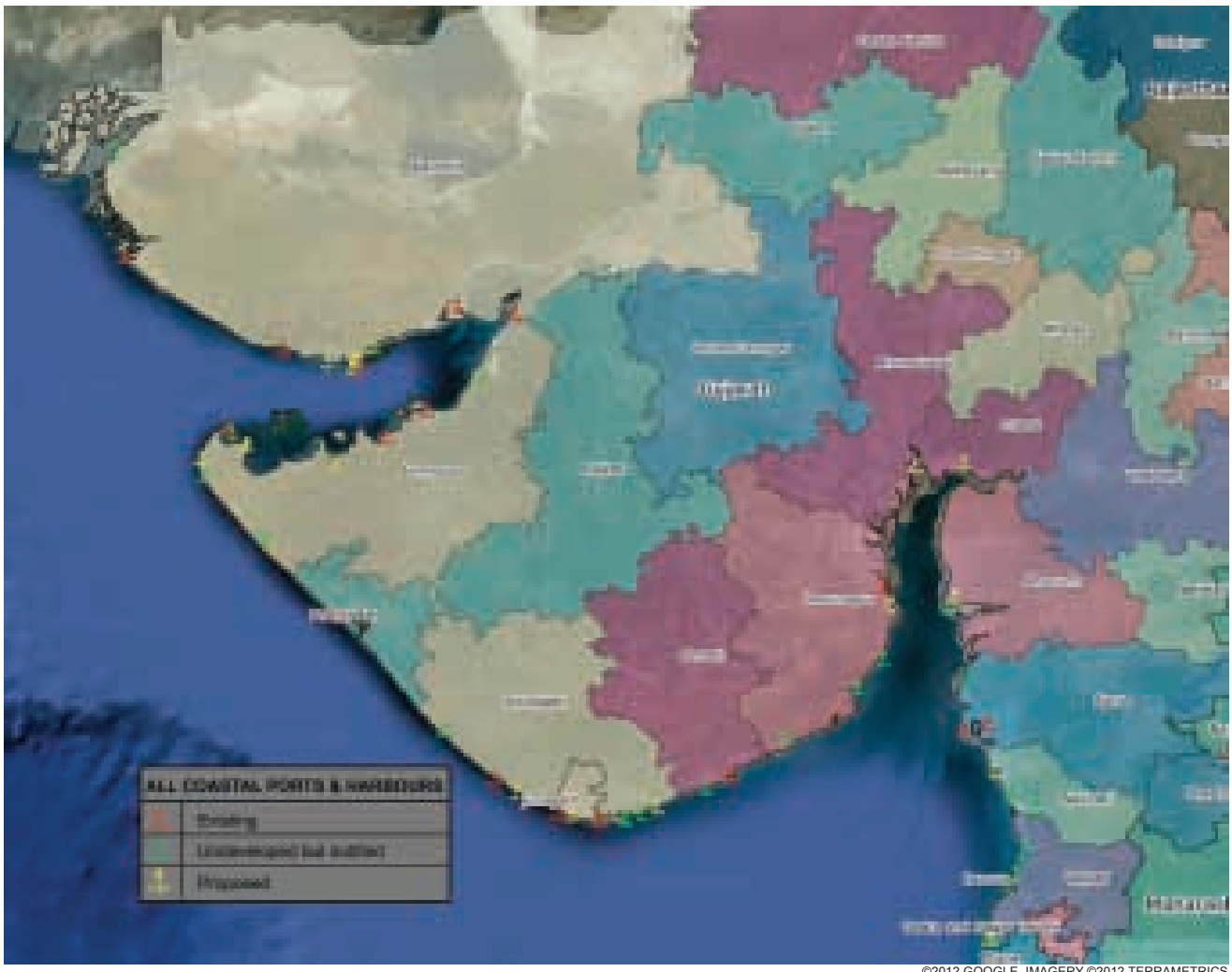


Figure 9.1.4: Ports & Harbours

Thermal power plants: Gujarat has eight thermal power plants near the coast, which are mostly old systems and relatively small compared to many of the new ones that are being planned.

Table 9.1.13: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	District	Type	Project name
1	Anand	Gas and liquid fuel	Dhuvaran Gas Based CCPP-I
2	Anand	Thermal-coal	Dhuvaran Thermal Power Station
3	Jamnagar	Thermal-coal	Sikka Thermal Power Station
4	Kachchh	Thermal-coal	Akrimota Thermal Power Station
5	Kachchh	Thermal-coal	Mundra Thermal Power Station Kutch
6	Surat	Gas and liquid fuel	Kawas TPS
7	Surat	Gas and liquid fuel	Essar Combined Cycle Power Plant
8	Surat	Gas and liquid fuel	GSEG Combined Cycle Power Plant

In addition to the 15 plants listed in the table for which information is available, there are 10 proposed plants for which the location given is incorrect, 2 for which no coordinates are available and 9 for which the given coordinates are the same as others listed under different names.

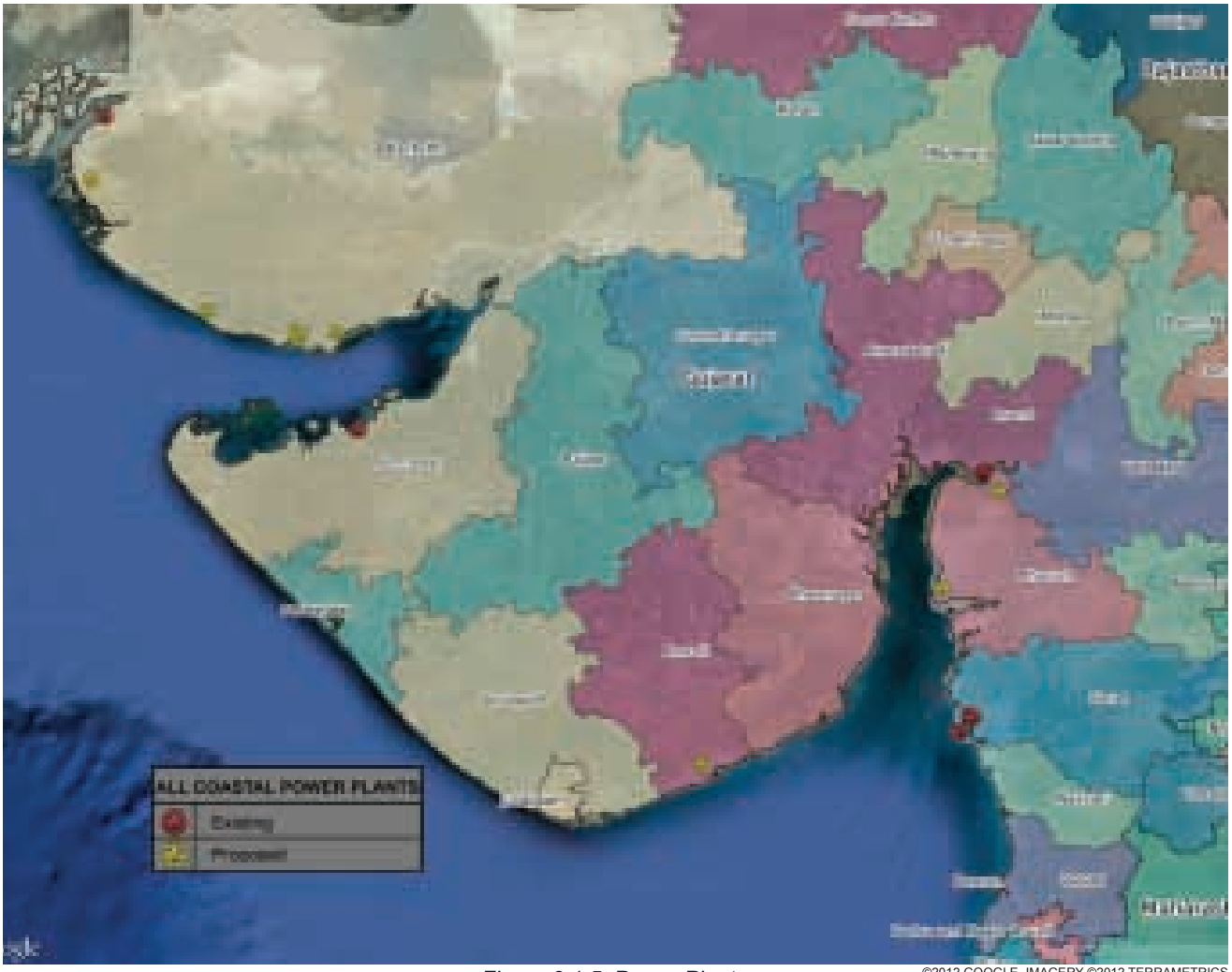


Figure 9.1.5: Power Plants

Table 9.1.14: Proposed thermal power plants

Proposed power plants - coastal					
	Fuel	**District**	**Village**	**Company**	**Ownership**
1	N.A.	Anand	Dhurvan	NTPC Ltd.	Central
2	Coal	Bharuch	Dahej	Adani Power Dahej Limited	Private
3	Gas	Bharuch	Vagra	Assam Company India Ltd.	Private
4	Coal	Bhavnagar	Padva	Bhavnagar Energy Company Ltd.	Private
5	Coal	Jamnagar	Pirodia	Essar Power Gujarat Ltd.	Private
6	Coal	Jamnagar	Bhatvadia	Universal Crescent Power Pvt. Ltd.	Private
7	Coal	Junagadh	Kaj / Nanavada	Shapoorji Pallonji Energy (Gujart) Pvt. Ltd.	Private
8	Coal	Kachchh	Mundra	Adani Power Ltd.	Private
9	Coal	Kachchh	Tuna Vara	CLP Power India Pvt. Ltd.	Private
10	Coal	Kachchh	Mota Layja	Nanalayja Power Com. Ltd.	Private
11	Coal	Kachchh	Sanghipuram	Sanghi Energy Ltd.	Private
12	Coal	Kachchh	Bhadreswar, Taluka Mundra	Adani - Kutch Power Generation Ltd	Private
13	Coal	Surat	Bhaga	NLC Gujarat Power Corporation Ltd.	Private-Cooperative
14	Coal	Surat	Suvali	Essar Hazira Power SEZ Ltd.	Private
15	Coal	Surat	Ukai	GSECL	State

Special Economic Zones (SEZ): There are 55 SEZs at present in Gujarat, covering an area of approximately 27,125 ha. The port of Kandla Special Economic Zone (KASEZ) was the first to be established in India and in Asia, way back in 1965, and covers 310 ha. SEZs in Mundra, Dholera, Dahej and Hazira are listed as port-based according to the Gujarat Maritime Board.

Mundra (Adani Ports and Special Economic Zone Limited (APSEZ)) is the largest, notified and functional port-based multi-product SEZ in India, spread over 100 km^2 in Kachchh. Dholera is to be a Special Investment Region (SIR), with a total area of 903 km^2. A notification has been issued for delineation of 879 km^2 of area as DSIR and a draft development plan was published on 05.01.2011[22]. Dahej SEZ Ltd (DSL) is promoted jointly by Gujarat Industrial Development Corporation (GIDC) and Oil & Natural Gas Corporation Ltd. (ONGC) for development of an SEZ. DSL is developing a multi-product SEZ at Dahej in Vagra Taluka of Bharuch district in Gujarat. Dahej SEZ covers a total land area of 1,732 ha of which 1,717 ha is processing area and 15 ha is non-processing area[23].

Challenges/issues in the coastal zone: Gujarat's rapid pace of coastal development has not been a smooth ride. There have been innumerable protests – especially over land acquisition and environmental clearances – over a number of ports in the private sector, such as Mundra, Dholera and Pipavav. Mundra is the Adani Ports and Special Economic Zone Limited (APSEZ), India's largest private port and special economic zone. In 2011, it was slapped with a show-cause notice by the Environment Ministry for serious violations of the Coastal Regulation Zone notification. NDTV[24] had exposed the cutting of hundreds of mangroves leading to their destruction. A long-standing agitation by the Machimar Adhikar Sangharsh Sangathan (MASS), Kachchh[25], Gujarat, against the Adani's Mundra port, the OPG Power Plant and others, has served to highlight the traditional fishing communities of Gujarat, especially the seasonal pagadia fishers who fish in the inter-tidal zone. The Kachchh coastline accounts for the longest coastline of Gujarat and is home to 3,500 fishing families. Mundra in the southern region of Kachchh is the smallest block, with a coastline of 72 km stretching across 10 coastal settlements, home to nearly 10,000 fisherfolk. However, their land is yet to be regularized[26]. Since they do not live there year round, it is easy to go there for a site inspection in the off-season and claim that the land is wasteland and there is no fishing in the area[27].

Dholera Port and SEZ is being jointly developed by J.K. and Adani Group as an all-weather commercial port in the Gulf of Cambay, Gujarat[28]. Until early last century, Dholera was a seafront with a deep water channel and tidal amplitude of the order of 10m. With the industrial revolution and demand for timber, especially to make wooden sleepers, forests disappeared. Soil erosion brought about by heavy rains and flooding brought the sediment to the Gulf of Cambay (Khambat), and the approach channels to Dholera became shallow and the port receded inland. Today it is a vast tidal flat and the villagers who live at the edge of the tidal flats have learnt to tend camels, grow cotton, collect salt, and so on. Now the whole economy of the place is likely to change with extensive coastal engineering. While there will be good happening in terms of 'development', it may also cause erosion and other problems around the seafront in areas that were 'safe'. Even worse are likely problems of vector-borne diseases[29,30]. Pipavav port is close to Jafrabad, a major fishing port. Negative impacts on the environment due to reclamation have been pointed out as long term and, in many cases, irreversible. While studies may point out the solution/mitigation measures, lack of compliance renders all mitigation measures to remain as part of plan documents[31]. Another proposed port that was protested against was at Maroli, because

22 Dholera SIR. http://dholerasir.com

23 Dahej SEZ. http://www.dahejsez.com

24 NDTV Save the coasts campaign. http://www.youtube.com/watch?v=zC89vp0EWs0&feature=relmfu video uploaded on March 2, 2011

25 Machimar Adhikar Sangharsh Sangathan (MASS), Kachchh, Gujarat. http://masskutch.blogspot.in/

26 Fishing in the Mundra coast. http://masskutch.blogspot.in/2009_05_01_archive.html#7913755446319173919 accessed 24 Aug. 2012

27 Kohli, K. RTI and EIA collide at NIO. India Together. 14 September 2010. http://www.indiatogether.org/2010/sep/env-nioeia.htm accessed 30 Sept. 2010.

28 Dholera Port http://www.gmbports.org/showpage.aspx?contentid=1520

29 Sudarshana, R. Planning for port development / Dholera-India. http://www.csiwisepractices.org/?read=10 accessed 10 Aug. 2012.

30 Asher, Manshi and Patrik Oskarsson. Se(i)zing the coast and the countryside. http://www.india-seminar.com/2008/582/582_manshi_patrik.htm accessed 24 Aug. 2012.

31 Aquatech Enviro Engineers, Bangalore. 2011. Executive Summary of EIA report on APM Terminal, Gujarat Pipavav Port Ltd. http://www.indiaenvironmentportal.org.in/files/file/GPPLtd_Exe_Summ_English.pdf retrieved 18 July 2012.

over 100,000 people in the Umargaon Taluka depend on fishing for a livelihood. They felt that '… construction of a port in this region would lead to a drastic reduction in marine life and hence thousands of fishermen will be deprived of their livelihood. Poor fishermen fish for prawns, crabs, etc, in the marshy lands, which span thousands of acres in this region. This land is held by the government in a sort of trust for the people and cannot be given away, sold or leased for commercial purposes against the public interest. This land will be destroyed due to the construction of the lagoon harbour'[32].

As in the case of ports, thermal power plants have also run into difficulties. In February 2012, the National Green Tribunal put on hold the Bhadreshwar thermal power plant at Mundra in Gujarat. It has asked the project proponent, OPG Power Gujarat Pvt Ltd, to stop all work at its 300 MW power plant till it gets the requisite environmental clearance. The tribunal passed the order on petitions by fishermen, salt pan workers and local residents who opposed the environmental clearance granted to the power company by the Gujarat State Level Impact Assessment Authority (GSLIAA) on 11 June 2010 for setting up the plant. They said the clearance was granted without taking note that the project area includes reserve forest[33]. A pipeline that will carry sea water to the plant was to pass through three hectares of forest land[34]. Down to Earth also carried out a review of the EIA for a 4,000 megawatt (MW) coal-based thermal power plant to come up at Bhatvadia village, Kalyanpur Taluka of Jamnagar district in Gujarat, on land declared as barren wasteland. The project also includes a captive coal jetty with breakwaters, conveyors, etc. The EIA recognises that due to its coastal location, major fishing activity takes place in villages of the study area in the Gulf of Kachchh. The water requirement for the project is pegged at 897,890 m^3/day and 631,676 m^3/day of wastewater would be generated, partly used for ash and coal handling plant, and the rest would be disposed off about 1.08 km from the shore. The analysis points out that while the EIA report clearly mentions that 8 out of the 40 faunal species belong to Schedule II and one to Schedule III of the Wildlife (Protection) Act, 1972, implying absolute protection, the report does not mention/predict any impact of the project on these species, nor does it suggest any protective measures[35]. In addition to these problems are oil spills, some of them routine due to tanker transport in the region, others with no traceable cause, but all of them causing concern to fishermen, enviromentalists and tourists[36].

9.2. Daman & Diu

Introduction: The erstwhile Portuguese enclaves of Daman and Diu (along with Goa, Dadra and Nagar Haveli) became an integral part of India on 19 December 1961. They were administered as one unit till 1987, when Goa was granted statehood, leaving Daman and Diu as a separate union territory; each enclave constitutes one of the union territory's two districts. Before conquest by the Portuguese, they were part of Gujarat, and traditionally carry on the life pattern of Gujarat and Saurashtra cultural region.

The U.T.'s surveyed length of the coastline is about 34 km. This is indicated in table 9.2.1.

Table 9.2.1: Length of coastline

Length of Coastline - Daman & Diu		
Districts	Length (Surveyed)	Length (Natmo)
Diu	22.1	14.0
Daman	12.3	12.0
Grand Total	**34.4**	**26.0**

32 Umargam Port ! More losses than benefits !! http://www.gujaratplus.com/environment/umargam/umargaon.html accessed 25 Aug. 2012.

33 CSE. CSE analyses: EIA report of thermal power project, Bhadreshwar, Kachchh, Gujarat. http://www.cseindia.org/content/cse-analyses-eia-report-thermal-power-project-bhadreshwar-kutch-gujarat accessed 24 Aug. 2012

34 Sambyal, Swati Singh. National Green Tribunal stays thermal power plant in Gujarat. http://www.downtoearth.org.in/content/national-green-tribunal-stays-thermal-power-plant-gujarat accessed 24 Aug. 2012.

35 CSE. EIA analysis of a 4,000 MW thermal power plant (Gujarat). http://www.cseindia.org/sites/default/files/EIA%20analysis%20TPP.pdf accessed 24 Aug. 2012.

36 Mysterious crude oil spill along Gujarat coast affects fishing, tourism. http://infochangeindia.org/environment/news/mysterious-crude-oil-spill-along-gujarat-coast-affects-fishing-tourism.html accessed 24 Aug. 2012.

Ecology and biodiversity: Little information is available on the ecology and biodiversity of Daman & Diu. Like all coastal areas, Daman too has water bodies which have been mapped in the study and given in the table below.

Table 9.2.2: Water bodies surveyed for this study

Water Bodies of Daman and Diu								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Daman	2	-	0.6	0.2	4.9	3.6	5.0	3.7
Diu	1	-	-	-	-	-	-	-
Grand Total	**3**	-	**0.6**	**0.2**	**4.9**	**3.6**	**2.3**	**1.7**

Fishing is important because of the seashore-based communities. The population of the fishing community is 40,016 according to the CMFRI 2010 census. There are 7,374 fishermen families, of which 7,181 belong to the traditional fishing community. 333 families are listed as BPL. There are 11 fishing hamlets spread around the two districts of Daman and Diu. The coastal settlements of Daman were mapped in the study and are given in the table.

Table 9.2.3: Settlements surveyed for this study

Settlements of Daman and Diu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Daman	8	6.9	2.3	56.0	37.4	57.4	38.3
Diu	-	-	-	-	-	-	-
Grand Total	**8**	**6.9**	**2.3**	**20.0**	**13.4**	**26.5**	**17.7**

Commercial Areas: The district industries centre of Daman and Diu has a variety of policies that are designed to attract investors. They describe a place that is pollution free and also indicate that no polluting industry of any kind is permitted[37]. Commercial spaces were mapped in this study, as shown in the table below.

Table 9.2.4 Commercial areas surveyed for this study

Commercial Areas of Daman and Diu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Daman	5	4.1	0.6	33.3	8.9	34.2	9.1
Diu	-	-	-	-	-	-	-
Grand Total	**5**	**4.1**	**0.6**	**11.9**	**3.2**	**15.8**	**4.2**

37 Daman and Diu. http://www.dcmsme.gov.in/policies/state/damandiu/pstdd01x.htm Accessed 25 August 2012.

Coastal structures: Until not so long ago, the coastline of Daman & Diu was clubbed with that of Goa for various purposes, including extent of erosion. Hence figures for Daman and Diu are not available separately. Structures mapped in the littoral zone include seawalls (rubble-mounded and RCC), jetties (RCC) and a bridge that connects Moti and Nani Daman. Seawalls have been used to protect urban settlements and tourist areas. This study mapped the length of seawalls and other structures in the littoral zone, as given in the table below. The study also mapped all structures in the littoral zone, as given in the table below.

Table 9.2.5: Structures surveyed for this study

Structures of Daman &Diu									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Daman	-	1	-	-	-	2	-	-	3
Diu	-	-	-	-	-	-	-	-	-
Total Nos.	-	**1**	-	-	-	**2**	-	-	**3**
Total length of structures (km)	-	**0.3**	-	-	-	**1.5**	-	-	**1.8**

Table 9.2.6: Seawalls & groynes surveyed for this study

Seawalls & Groynes of Daman & Diu						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Daman	9	6.1	49.4	50.7	-	-
Diu	-	-	-	-	-	-
Grand Total	**9**	**6.1**	**17.7**	**23.4**	-	-

Ports and harbours: Daman has a small port which was mapped during the study detailed in the table below.

Table 9.2.7: Ports surveyed for this study

Ports & Harbours of Daman and Diu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Daman	1	0.5	-	4.1	0.1	4.2	0.1
Diu	-	-	-	-	-	-	-
Grand Total	**1**	**0.5**	**-**	**1.5**	**0.1**	**1.9**	**0.1**

Challenges/issues in the coastal zone: The policies of this tiny union territory designed to attract investors is of concern. Already, almost half the length of the coast is armoured with a seawall and more than half of the coast within the 500m zone is occupied by settlements. Unplanned activities in the coastal zone should not result in increased deterioration of the coast which is already under considerable pressure of development.

9.3. Maharashtra

Introduction: Maharashtra is the third largest state in the country both in terms of size and population. The length of the coastline surveyed in this study is about 900 km long. A district-wise breakup of coastal lengths is provided in table 9.3.1 comparing them with NATMO measurements. In some of the districts, there appear to be significant differences between the lengths of coastline measured during our survey and those recorded by NATMO. A considerable variation is to be expected when measuring lengths of coastlines that are non-linear and irregularly shaped, when different scales are used for making the measuring. Along linear and regularly shaped alignments of the coastline, the differences are likely to be less.

Table 9.3.1: Length of coastline

Length of Coastline - Maharashtra		
Districts	Length (Surveyed)	Length (Natmo)
Thane	137.0	123.0
Sindhudurg	136.0	109.0
Ratnagiri	293.0	172.0
Raigad	197.0	182.0
Mumbai Suburban	138.0	43.0
Mumbai City	0.0	37.0
Grand Total	**901.0**	**666.0**

The long indented coastline is characterized by pocket beaches flanked by rocky cliffs of Deccan basalt, estuaries, and patches of mangrove. It comprises the coastal districts of Thane, Raigad, Greater Mumbai, Mumbai, Ratnagiri and Sindhudurg, all of which come under the Konkan administrative division. The Sahyadri Western Ghats run parallel to the coast. The main rivers flowing through the state are Godavari, Bhima and Krishna. Only 17% of the total coast is sandy, 37% is rocky, and 46% has mudflats. In 2004, the length of coastline affected by erosion was given as 263 km – about **40%** of the coast. Maharashtra is one of the most industrialized and urbanized states of India. About 42% of the state's population is living in urban areas, though the levels of urbanization are uneven across regions and districts within the state. Both inter-state and intra-state migrations are responsible for enormous growth of urban populations. The mega-city of Mumbai is located in Maharashtra, and is also the state capital. While the overall population density of the state is 365 per km^2 (2011 census), the density of Mumbai is 20,038 per km^2, that of Mumbai suburban is 20,925 per km^2.

Maharashtra's coastal vulnerability to cyclones and earthquakes was evaluated by the BMTPC. Most of the coast comes under the 'moderate risk' zone for wind and cyclones with the southern stretch coming under 'low damage risk' zone, while the central stretch of the coast comes under the 'high damage risk' zone for earthquakes.

Ecology and biodiversity: The Maharashtra coast – popularly known as Konkan coast – is an important sector on the west coast of India, because of its physical distinctiveness, biota and marine resources. The coastal areas are populated and developed in the active region of Konkan. The coastal region is hilly, narrow, highly dissected with transverse ridges of the Western Ghats and at many places extending as promontories, notches, sea caves, embayments, submerged shoals and offshore islands[38].

Among the west coast states, Maharashtra has the most diversified mangrove flora, composed of 19 species. Distribution of mangroves in Maharashtra can be broadly classified as follows: river dominated - Vashishthi, Shastri and Savitri; along the tidal estuaries and creeks (the most dominant form in the state) such as Thane, Panvel, Dharamtar, Rajapur, Jaigad, Devgad, Achra and Kalwali; mangroves of backwaters, bays or very small tidal inlets, for example Valvati near Shreevardhan in Raigad district; mangroves on rocky/ sandy substrata which are relatively rare – a patch is reported near Hareshwar (Kalinje); and island vegetation restricted to islands of Bucher and Elephanta around Mumbai, plus some smaller islands located in the larger estuaries[39].

38 Ecologically Important Areas of Maharashtra Coast. http://www.annauniv.edu/iom/iomour/EIA%27s%20Maharashtra.htm

39 Shindikar, M. Coastal areas – problems and conservation in Maharashtra with special reference to mangroves. http://envis.maharashtra.gov.in/envis_data/pdf/Comptn09/Art_MRShindikar_1st.pdf accessed 25 Aug. 2012.

Untawale et al.[40] have recorded 91 marine algal species along the Maharashtra coast. Malvan had the maximum number of marine algal species (73) followed by Colaba, Mumbai (64) and Ratnagiri (56). Species belonging to genera such as Monostroma, Gelidium, Gracilaria, Sargassum, etc, were found to be exploited, as they are commercially important. Others are rare, and the authors suggest conservation by modern techniques. The open sandy beaches with fine to medium sand provide ideal pore space for the development of rich and diverse interstitial fauna. In general, the benthic macrofauna was dominated by polychaetes, both in terms of density and diversity (till this date >72 species are reported from the area). Molluscs and crustaceans were represented by many important species that are commercially important. Recently Bhave and Apte (2011)[41] reported 15 new records of Opisthobranchs to India and 8 new records to Konkan from this region. Bhave and Apte (unpublished data) further discovered 80 records of Opisthobranchs new to Konkan. Untawale et al. also recommended five sites as Marine Protected Areas: Malvan, an open coast ecosystem dominated by rocky outcrops with intermittent sandy beaches, Achra-Devgad-Vijaydurg, Ratnagiri, Colaba and Vikhroli.

Table 9.3.2: List of wetlands[42]

Wetlands of Maharashtra							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Mumbai Suburban	106	24	-	28	-	25	164
Mumbai Urban	-	12	-	-	-	-	-
Raigarh	680	92	-	48	-	-	303
Ratnagiri	194	94	-	205	-	-	104
Sindhudurg	79	45	-	75	-	-	43
Thane	192	23	-	34	-	4	126
Grand Total	**1251**	**290**	-	**390**	-	**29**	**740**

Table 9.3.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of Maharashtra							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Mumbai City	-	-	-	-	-	-	-
Mumbai Suburban	-	-	-	-	-	-	-
Raigad	-	-	-	-	-	-	-
Ratnagiri	-	-	-	-	-	-	-
Sindhudurg	1	5	3.0	3.7	4.3	4.6	5.4
Thane	-	-	-	-	-	-	-
Grand Total	**1**	**5**	**3.0**	**0.6**	**0.7**	**0.8**	**0.9**

The Malvan (Marine) Wildlife Sanctuary was designated in 1987, and covers an area of 29.12 km^2, with a core zone of 3.18 km^2. The core zone includes the Sindhudurg fort, Padamged island and other submerged rocky structures. The core zone is used for anchoring fishing vessels and for fishing by a small number of hook-and-line fishermen. The buffer zone has seven villages, with a population of over 7,000 that depends on fishing for a livelihood. Though the sanctuary has been designated, it exists mainly on paper, as the regulations have not been implemented[43].

40 Untawale, A.G., V.K. Dhargalkar and G.V. Deshmukhe. 2000. Prioritization of Potential Sites for Marine Biodiversity. Conservation in India. Setting biodiversity conservation priorities for India: Summary of the findings and conclusions of the biodiversity conservation prioritization project, eds. Singh, S.; Sastry, A.R.K.; Mehta, R.; Uppal, V.Vol.1; 104-131p. http://drs.nio.org/drs/bitstream/2264/1614/2/Setting_Biodiversity_Conserv_Priorities_India_2000_1_104.pdf accessed 26 Aug. 2012.

41 Bhave, V.J and Deepak Apte (2011) Opisthobranch fauna of Ratnagiri, Maharashtra, India, with 8 new records to India. *Journal of Mumbai Natural History Society* 108 (3): 172-182.

42 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

43 Rajagopalan, Ramya. Marine Protected Areas in India. Samudra Monographs. ICSF. 2008.

Table 9.3.4: Water bodies surveyed in this study

Water Bodies of Maharashtra								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ratnagiri	34	1	20.7	5.2	7.1	3.5	12.0	6.0
Sindhudurg	18	1	12.9	4.0	9.5	5.9	11.9	7.4
Thane	22	1	16.0	5.1	11.7	7.5	13.0	8.3
Mumbai Suburban	6	2	3.8	1.3	2.8	1.9	8.8	6.1
Mumbai City	-	-	-	-	-	-	-	-
Raigad	1	7	4.8	1.9	2.5	2.0	2.7	2.1
Grand Total	**81**	**12**	**58.3**	**17.6**	**6.5**	**3.9**	**8.8**	**5.3**

Coastal settlements: This project mapped the space and length of the coastline occupied by coastal settlements up to 500m from the shoreline.

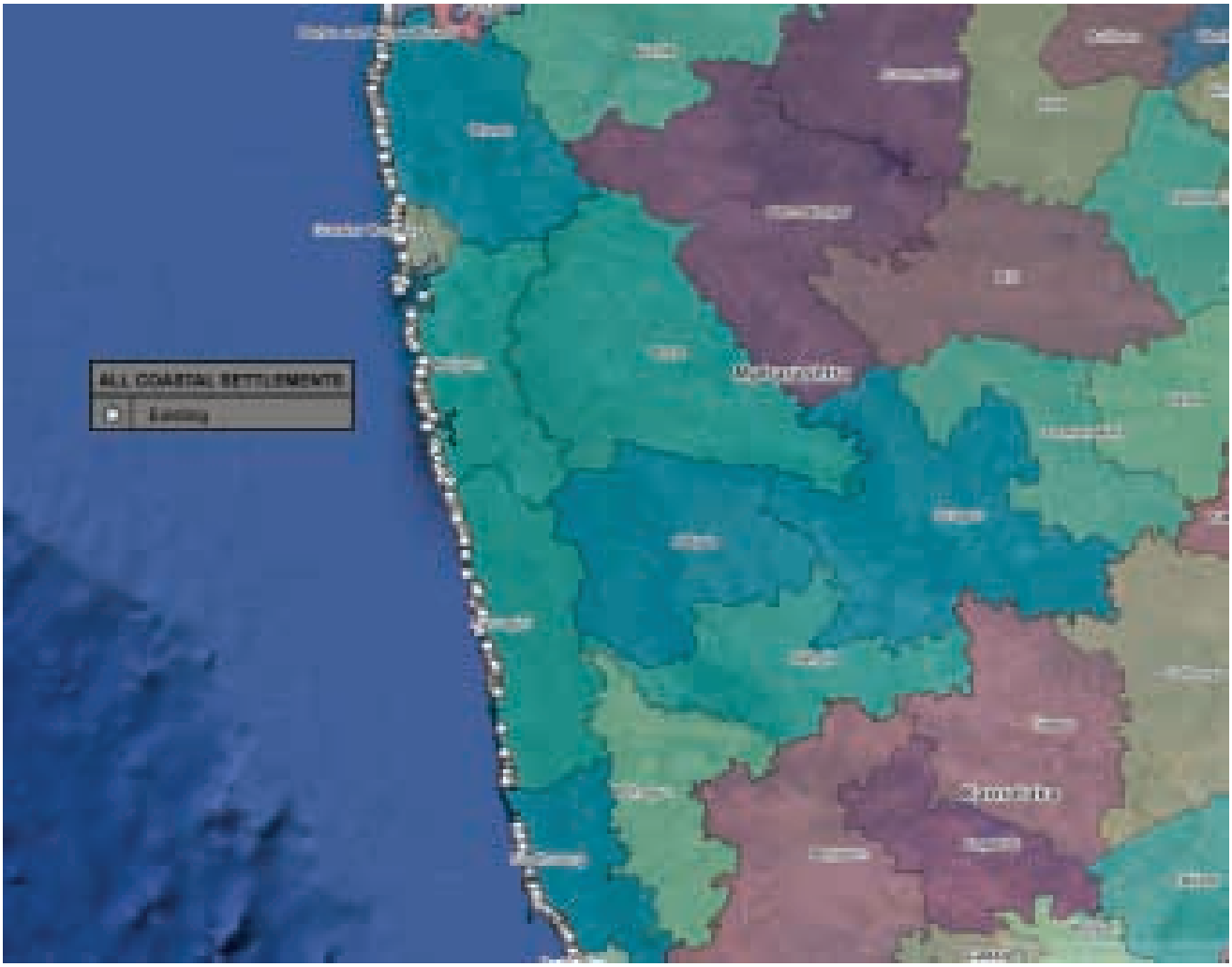


Figure 9.3.1: Settlements

The result is presented in a table below.

Table 9.3.5: Settlements surveyed in this study

Settlements of Maharashtra							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Thane	42	34.5	8.3	25.2	12.1	28.0	13.5
Ratnagiri	46	37.3	9.3	12.7	6.4	21.7	10.9
Sindhudurg	30	19.4	4.1	14.3	6.0	17.8	7.5
Raigad	36	35.9	9.1	18.2	9.3	19.8	10.0
Mumbai Suburban	15	22.2	12.2	16.1	17.7	51.7	56.7
Mumbai City	-	-	-	-	-	-	-
Grand Total	**169**	**149.4**	**43.0**	**16.6**	**9.6**	**22.4**	**12.9**

Table 9.3.6: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
Thane	77	26,821	26,331	4,231	121,869
Greater Mumbai	30	9,304	9,138	624	40,953
Ratnagiri	98	14,064	12,541	2,089	66,685
Raigad	168	24,026	20,448	5,864	123,574
Sindhudurg	83	7,277	5,745	2,701	33,178
Maharashtra	456	81,492	74,203	15,509	386,259

Fishing: Maharashtra, with a 720 km coastline and 112,000 km^2 of continental shelf[44], is one of the leaders in fish production. The marine fish landings in Maharashtra during 2010 have been estimated provisionally at 2,25,000 tonnes, of which the major share came from trawling sector (51.4%) followed by dol net (24.6%), purse seine (12.4%), gillnet (11.2%), hook and line (0.02%) and non-mechanized sector (0.5%). When compared to 2009, the total marine fish landings showed a decline of 29%, while total number of units landed and the actual fishing hours showed 33.5% and 22.3% decline respectively[45]. The CMFRI census related to the marine fishing community population is given in the table below.

Commercial Areas: In addition to coastal settlements, space used for commercial purposes was also mapped.

Table 9.3.7: Commercial areas surveyed in this study

Commerical Areas of Maharashtra							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ratnagiri	28	6.3	1.3	2.2	0.9	3.7	1.5
Sindhudurg	10	2.9	0.5	2.1	0.7	2.6	0.9
Thane	19	6.9	1.3	5.0	2.0	5.6	2.2
Mumbai Suburban	55	23.9	4.9	17.4	7.1	55.7	22.7
Mumbai City	-	-	-	-	-	-	-
Raigad	23	9.6	2.0	4.9	2.1	5.3	2.2
Grand Total	**135**	**49.6**	**10.0**	**5.5**	**2.2**	**7.5**	**3.0**

44 Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Government of India. http://www.dahd.nic.in/dahd/WriteReadData/Fisheries%20States%20Profile/Maharashtra.pdf

45 CMFRI Annual Report 2010-2011. www.cmfri.org.in

Salt: Traditionally, mangrove swamps were converted into salt pans in Thane and Mumbai. Along the coast of Maharashtra, saltpans occupy about 5,271 acres and employed over 2,000 workers and 20,000 people in allied works. Salt production is practiced at Bhayandar, Palghar, Vasai, Dahanu and parts of the Borivali-Mira road stretch in Thane district. As a result of pollution created by the industrial operations in this area, salt making industries get low quality water for salt production. Hence the salt works in many areas have been closed down[46].

Coastal structures: Bridges, piers, breakwaters, detached breakwaters, elevated roads, seawalls and jetties are the major structures in the littoral zone. They are either rubble-mounded or RCC. The seawalls have been constructed mainly to protect beaches (e.g. Tondavali beach Malvan, Sagareshwar beach). A summary of the length of structures mapped in this study is given in the table below. According to the CPDAC (Table 8.7), 127 km of the coast is protected. This study gave the length of seawalls as being only 58 km.

Table 9.3.8: Structures surveyed in this study

Structures of Maharashtra									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Mumbai	4	2	-	-	-	3	13	-	22
Raigad	5	2	-	-	-	2	4	-	13
Ratnagiri	3	5	-	-	-	-	11	-	19
Sindhudurg	-	-	1	-	1	1	5	-	8
Thane	6	-	-	-	-	-	9	1	16
Total Nos.	**18**	**9**	**1**	-	**1**	**6**	**42**	**1**	**78**
Total length of structures (km)	**7.5**	**6.5**	**0.2**	-	**1.2**	**2.0**	**9.0**	**0.7**	**26.9**

Table 9.3.9: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Maharashtra						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Mumbai City	-	-	-	-	-	-
Mumbai Suburban	27	25.9	18.7	60.1	-	-
Raigad	13	14.1	7.2	7.7	2	0.3
Ratnagiri	10	4.5	1.5	2.6	2	0.6
Sindhudurg	7	5.4	4.0	5.0	-	-
Thane	29	8.5	6.2	6.9	4	2.1
Grand Total	**86**	**58.3**	**6.5**	**8.8**	**8**	**3.0**

46 Shindikar, M. Coastal areas – problems and conservation in Maharashtra with special reference to mangroves. http://envis.maharashtra.gov.in/envis_data/pdf/Comptn09/Art_MRShindikar_1st.pdf accessed 25 Aug. 2012.

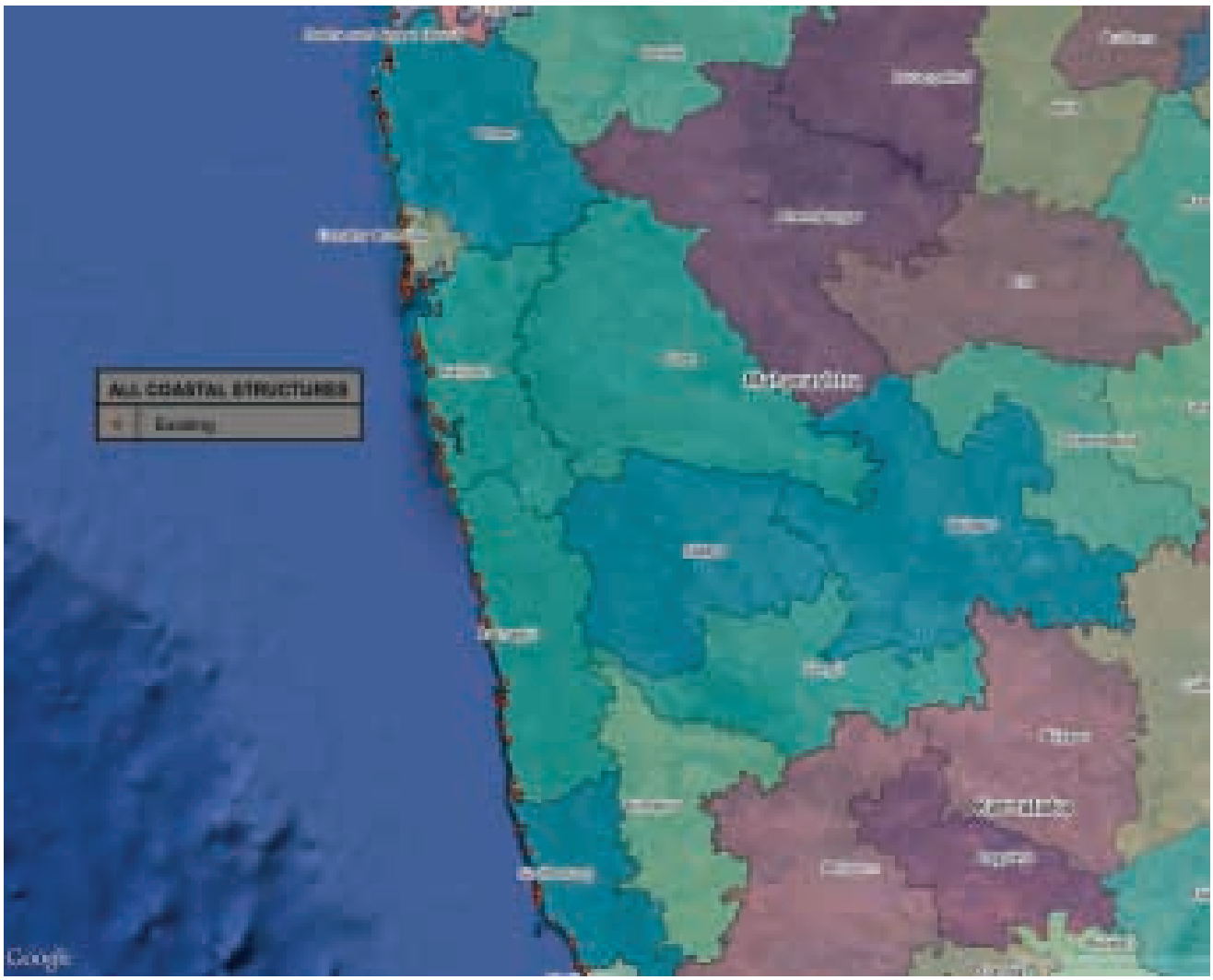


Figure 9.3.2: Structures

Ports and Harbours: The Maharashtra Maritime Board's major activity is the development of minor ports and harbours for promoting economic activity along the coastline. According to the MMB, Maharashtra, with its vast coastline 35 creeks and rivers, is an attractive destination for investors to develop various water-front projects, be they ports, port-related infrastructure, inland waterways, or water sports complexes. The developments are listed under port projects, multipurpose terminals, captive jetties, shipyards, inland water transport, marinas, and tourism and water sports[47].

Two of the major ports of the country are located in this state: Mumbai Port (MbPT) which is a natural deep water harbour, and Jawaharlal Nehru Port (JNPT), which is the largest container port in India. In addition, there are 48 minor ports which fall into 5 groups, namely Bandra Group (9 ports), Mora group (11 ports), Rajpuri group (9 ports), Ratnagiri group (11 ports), and Vengurla group (8 ports). At present only 8 minor ports are in operation. In order to provide multi-user port facilities, Maharashtra government has decided to develop 6 minor ports: Rewas-Aware and Dighi in Raigad district, Dhamankhol, Jaigad and Lavgan, Jaigad in Ratnagiri district, and Vijaydurg and Redi in Sindhudurg district[48]. Of these, the development of Rewas-Aware and Dighi ports is already in progress through private sector participation. There are 3 multipurpose terminals in operation: Karanja (Dharmantar), Jaigad (Lavgan) and Jaigad (Katale). Four captive terminals are in operation at Panwel (Ulwa-Belapur), Alibaug (Dharmantar), Revdanda and Ratnagiri (Pawas-Ranpar). There are 2 projects in progress and 5 for which permission has been given by the MMB. Two shipyards at Usgaon, Dabhol, and Bhagwati Bunder, Ratnagiri, are in operation, but 10 more have been given permission. Five sites have been shortlisted around Mumbai for marinas: Mandwa, Belapur, Vasai Creek, Malad Creek and Dharmantar Creek.

47 Maharashtra Maritime Board. http://www.mahammb.com

48 Ports and Logistics. Maharashtra – the strategic hub for maritime business. http://www.midcindia.org/Sector%20Profile/Ports%20and%20Logistics%20Sector.pdf

The total space and coastline occupied by some of the ports as measured by this project are given in the table below.

Table 9.3.10: Ports surveyed in this study

Ports & Harbours of Maharashtra							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Mumbai City	-	-	-	-	-	-	-
Mumbai Suburban	-	-	-	-	-	-	-
Raigad	10	8.0	2.5	4.1	2.5	4.4	2.7
Ratnagiri	9	6.6	3.2	2.3	2.2	3.8	3.7
Sindhudurg	7	1.4	0.1	1.1	0.2	1.3	0.2
Thane	18	21.2	6.1	15.5	8.9	17.3	9.9
Grand Total	**44**	**37.3**	**11.9**	**4.1**	**2.6**	**5.6**	**3.6**

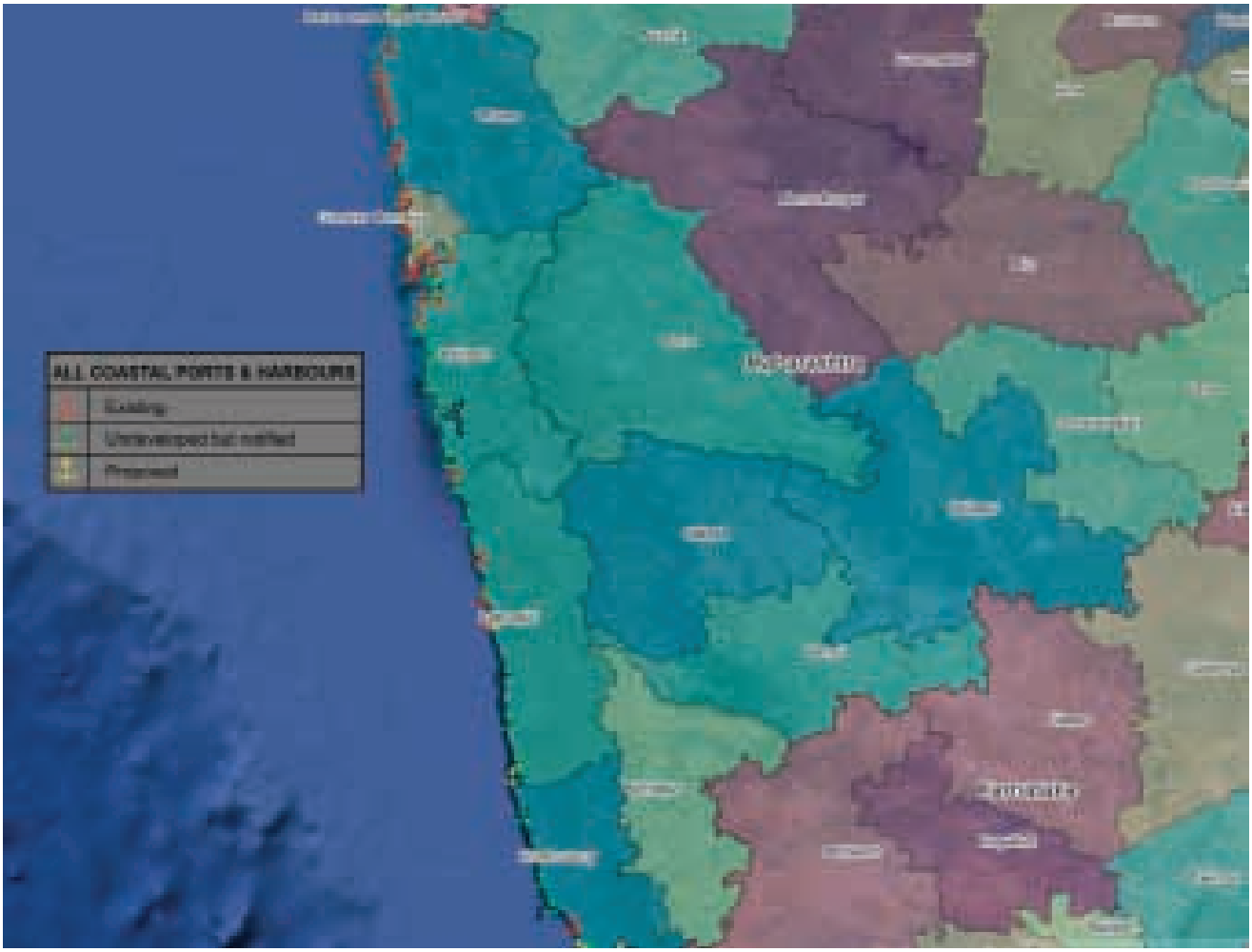


Figure 9.3.3: Ports

Table 9.3.11: Proposed ports

Proposed ports		
No. of ports State	**District**	**Total**
Maharashtra	**Mumbai**	1
	Ratnagiri	1
	Sindhudurg	2
Total		**4**

Maharashtra's two major ports, JNPT and MbPT, provide the largest port facilities in India, and together handle a major share of export-import activities in India. The state handled the maximum container traffic and the second largest POL cargo in India in 2009-10. In fact JNPT, which is an all-weather tidal port having 12 berths, of which 8 are dedicated to container traffic, handled 60% of India's container traffic, and plans to become India's first 'green' port. Expansion plans include a fourth container terminal, development of a standalone container facility, deepening of the main harbour channel for accommodating 14 m draught vessels, and a 400-acre port-based SEZ. Mumbai Port Trust is the second oldest major port in India and is a natural harbour port with impounded wet docks. It has 753 ha under its control. Plans are under way to increase the capacity of the port – including dredging and infrastructure development – to handle larger ships, with a total investment of Rs. 3,532.76 crores.

Maharashtra's Greenfield Port Policy of 2010 is based on the BOOST (Build, Own, Operate, Share and Transfer) model and envisages an investment of Rs. 22,775 crores in its minor ports. Of the six ports being developed, Dighi Port also covers a multiproduct SEZ, including a Free Trade Warehousing Zone.

Thermal power plants: Maharashtra has the maximum number of thermal power plants. With heavy industrial demand, a large number of companies are planning to set up coal- and gas-based projects to generate 35,000 MW. The coastal districts of Ratnagiri, Sindhudurg and Raigad are likely to become the power hub of the state. A lot of concern has been raised, because these are areas known for agricultural and horticultural production[49]. A case study about Ratnagiri district has been included in Chapter 6 of this report.

Table 9.3.12: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	District	Type	Project Name
1	Tarapur	Atomic	Tarapur Atomic Power Station
2	Raigad	Gas and liquid fuel	Uran Gas Turbine Power Station
3	Mumbai	Gas and liquid fuel	Trombay Gas Power Station
4	Mumbai	Thermal-coal	Trombay Thermal Power Station
5	Thane	Thermal-coal	Dahanu Thermal Power Station

Table 9.3.13 Proposed thermal power plants

Proposed power plants - coastal					
	Fuel	**District**	**Village**	**Company**	**Ownership**
1	Coal	Raigad	Madhekar	Patni Energy Pvt. Ltd	Private
2	Coal	Raigad	Dehrand	Tata Power Co. Ltd.	Private
3	Coal	Raigad	Dolvi	Ispat Energy Ltd.	Private
4	Coal	Raigad	Bankot	Hari Harieshwar Power Company Pvt. Ltd.	Private
5	Coal	Ratnagiri	Jaigad	JSW -Jindal Steel works Energy Ltd.	Private
6	Coal	Ratnagiri	Ranpar	Finolex Industries Ltd.	Private
7	Coal	Ratnagiri	Dhopave	MAHAGENCO	State
8	Coal	Ratnagiri	Guhagar Taluka	Tiana Power Projects Pvt. Ltd.	Private
9	Coal	Ratnagiri	Anjarie	Tiana Power Projects Pvt. Ltd.	Private
10	Coal	Sindhudurg	Dhakur / Ajgaon	India-Barath Power (Konkan) Ltd.	Private
11	Gas	Greater Mumbai	Dronagiri	Urban Energy Generation Pvt. Ltd.	Private
12	Gas	Raigad	Kandalgaon	AES (India) Pvt. Ltd.	Private
13	Gas	Ratnagiri	Ajnavel	NTPC Ltd.	Central
14	Gas	Ratnagiri	Gudghe & Pandheri	GMR Coastal Energy Private Ltd.	Private

In addition to the 14 proposed plants for which coordinates are available, for one proposed plant in Raigad district no coordinates are available, and six proposed plants are located 10 km away from the coast. An atomic power plant is to come up at Jaitapur in Ratnagiri district.

49 Jog, S. Coastal Maharashtra set to be India's new power hub. Business Standard, 12 Dec 2010. http://www.business-standard.com/india/news/coastal-maharashtra-set-to-be-india%5Cs-new-power-hub/417915/ accessed 25 Aug. 2012.

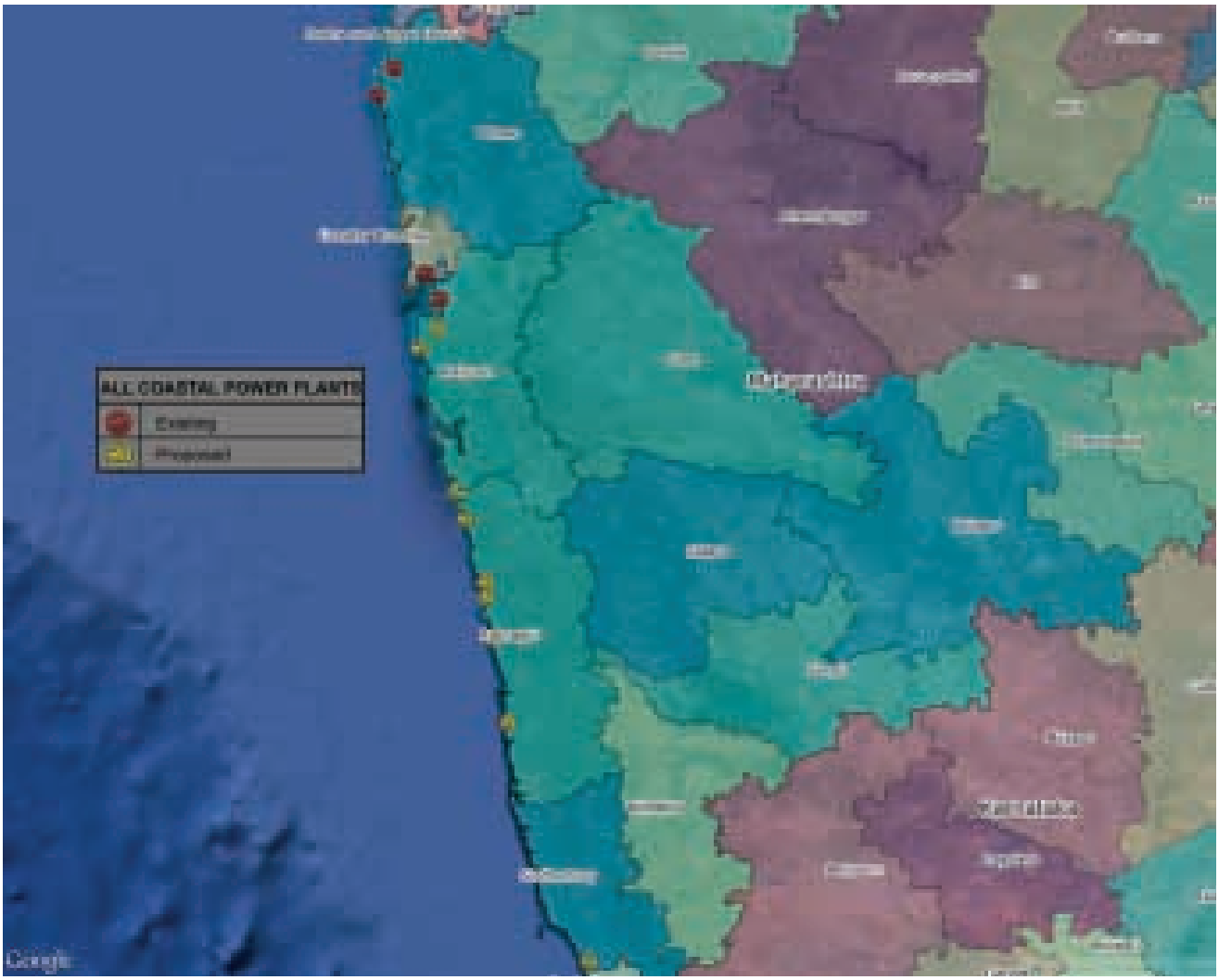


Figure 9.3.4: Power Plants

Special Economic Zones: In recent times, the trend in Maharashtra seems to have been going against SEZs. In May 2012, the Chief Minister of Maharashtra said that Maharashtra is in process of preparing an exit policy for SEZ developers, and then converting the surrendered land-banks into local industrial parks, as the Centre is unlikely to roll back its decision to tax such clusters[50]. Subsequently four SEZs have been reportedly cancelled because of strong opposition from the locals[51].

Challenges/issues in the coastal zone: Some of the major problems faced by the littoral zone and the shorefront areas of Maharashtra coast are related to coastal erosion, siltation, pollution, destruction of mangrove swamps, salt marshes, sea level rise, landslides and slope failure, pressure of population, industrialization, road transport, etc.

As mentioned earlier, almost 40% of the coastline of Maharashtra is eroding. The Asian Development Bank is to locate the first artificial reef in Maharashtra at Mirya Bay in Ratnagiri district. This is to help contain erosion in that area, which is supposed to have arisen because of the development of a fisheries harbour with two breakwaters in the southeast region of the bay on a sandy beach. As a result, there has been excessive accumulation of sand north of the north breakwater, and the approaches to the fisheries harbour are getting silted up, while there is severe erosion in the northern part of the bay, for which a seawall has been provided and now an artificial reef on the northern coast is planned[52]. The estimated cost is Rs. 62.51 crore at 2011 price level. This is being taken up as a pilot project under the National Coastal Protection Project of Government of India and will be reviewed

50 Maharashtra plans exit option for SEZs, to turn land into local parks. The Economic Times. 18 May 2012. http://articles.economictimes.indiatimes.com/2012-05-18/news/31765768_1_sez-promoters-sez-developers-prithviraj-chavan

51 Bowing to farmers' demand, Maharashtra cancels four SEZs. The Hindu, Mumbai, 30 July 2012. http://www.thehindu.com/news/states/other-states/article3703909.ece

52 Kudale, M.D., 2010. Impact of port development on the coastline and the need for protection. Ind. J. Mar. Sci. 39(4): 597-604.

in the post project scenario[53]. According to the project document, community land and housing along the north part of the bay will be protected. The reinstatement of the beach will allow landing access to fishing boats and opportunities for tourism. The reef will provide habitat for fish and fish breeding. The activities are:

1. Construction of offshore geotextile reef in the northern part of the bay. Single-layer, shore-perpendicular bags (volume: 10,060 m^3) will be used. Sand will be sourced from sand heaps near the harbour.
2. Beach nourishment of 450,000 m^3 to be placed on the beach and in shallow water inside the geotextile reef. Sand will be sourced from sand heaps, the harbour, and sand accumulated outside the harbour. The beach will provide a natural buffer against storms along the north and central part.

However, this project has come under criticism. The other projects at Goa and Kerala where geotextiles were used to create artificial reefs were reportedly not successful, with sections of the reefs being washed ashore[54].

Speaking in a conference over a decade ago, a well-known fisher leader lamented that in the name of development all kinds of projects were coming up in the coastal areas of Maharashtra, such as thermal power plants, amusement parks, construction of a sea-link bridge, airport, harbour, and a chemical industries zone. This was polluting the water and displacing fisher people almost every 10 km along the coastal belt of Maharashtra[55].

A recent case study about a thermal power plant to be located in the Dharmantar creek, Maharashtra, says that the plant would discharge 20,000 $m^3\ day^{-1}$ of heated effluent in the creek, leading to adverse impact on prevailing hydrological and biological features of the creek system. Moreover, the relevant infrastructure developments may require reclamation of ~0.11 km^2 of existing mangrove area, particularly along the crisscross network of water, as well as loss of potential flats for mangrove regeneration[56]. Despite these major reclamations, there are still patches left. Even these smaller patches offer habitats to wildlife, and are important.

The MoEF has declared Ecologically Sensitive Areas under the Environment (Protection) Act 1986. One of the first instances of the use of these legal provisions by the central government was Murud-Janjira, a coastal village in Raigad District of Maharashtra, in January 1989. The notification currently prohibits the location of industries in the region (except industries linked with tourism, for which environmental impacts are to be assessed) to preserve the mangrove ecosystem of Murud. However, the term 'ESA' was not used in that notification. The second ESA in Maharashtra is Dahanu. In 1988, Mumbai Suburban Electric Supply Limited (BSES) proposed to set up a 500 MW thermal power plant in Dahanu Taluka of Maharashtra. Alarmed by its environmental consequences, the residents of Dahanu filed a Writ Petition in the Mumbai High Court. The Mumbai High Court and later the Supreme Court permitted the setting up of the thermal power plant in their respective orders. However, local groups like the Dahanu Taluka Environment Protection Group (DTEPG) with assistance from groups like the Mumbai Environmental Action Group (BEAG) lobbied for the declaration of the area as an ESA. The notification was issued in 1991, but only after the thermal power plant was permitted; also it was the first time that the term 'Ecologically Fragile Area' was used in such a notification. However, it took a Supreme Court order in 1996 to finally constitute the Dahanu Taluka Environment Protection Authority (DTEPA) to monitor the compliance of the Dahanu ESA Notification. The DTEPA has actively examined the environmental impact of proposed development projects in the region, and has ensured the installation of a Flue Gas De-sulphurisation plant in the BSES Thermal Power Plant and prevented the establishment of a port in Dahanu. The DTEPA's role may have been facilitated by the fact that it has executive powers to safeguard Dahanu, is not under governmental control, and is answerable only to the Supreme Court. On the other hand, there are reports of proposals to locate industries in the Murud-Janjira region. Other ESAs in Maharashtra include Mahabaleshwar-Panchgani (2000) and Matheran

53 Central Water Commission, Government of India. Summary record of discussions of the 11th meeting of the advisory committee on irrigation, flood control and multi purpose projects, held on 20t July 2011 for consideration of technoeconomic viability of project proposals. http://www.cwc.gov.in/main/Download_Index/110tac%20min.pdf

54 NGO Forum on ADB and Kabani. India: Borrowing False Solutions? A Critique of Asian Development Banks' Sustainable Coastal Protection and Management Investment Program. July 2012. http://www.forum-adb.org/docs/OP_Aug 2012.pdf accessed 27 Aug. 2012.

55 Patil, Ram Bhau. Coastal zone conflicts in Maharashtra. FORGING UNITY: Coastal Communities and the Indian Ocean's Future Conference Organized at IIT Madras by ICSF and IOI. Chennai, India, 9 – 13 October 2001.

56 Kulkarni, V.A., V.S. Naidu and T.G. Jagtap. Marine Ecological Habitat. A case study on projected thermal power plant around Dharmantar creek, India. J. Environ. Biol. 32 (2011): 213-219.

(2003)[57]. ESAs and areas protected under the WLPA, CRZ 2011, etc, are important because there are clauses that prevent siting of industries within specified distances of such areas.

In Maharashtra, sensitive coastal lands are still owned by absentee landlords (Khots), who sell off land and thereby dispossess the actual cultivators. In Ratnagiri district, the Maharashtra Industrial Development Corporation (MIDC) reportedly has acquired large areas with high horticultural activity as well as marine biodiversity[58]. The other is of "Khar Land", the tidal land described variously as askhar, khajan, kharepat, gazni, etc, made cultivable or otherwise beneficial by protecting it by means of an embankment from the sea or tidal river. The master plan prepared in 1979 was to reclaim 67,422 hectares. As per the notification published on 25 December 2003, there were 575 khar land development schemes in four districts of Konkan to reclaim 49,120 hectares[59]. The current state of the reclamation is not available, but clearly this would result in extensive loss of coastal biodiversity.

PHOTO: DEBI GOENKA

Figure 9.3.5: A median egret with two pond herons in a patch that has survived the reclamation

The Konkan coast is under grave threat of overdevelopment, with at least fifteen proposed coal-fired power projects equalling 25 GW of power and one nuclear power plant of 10,000 MW set to be built on a narrow strip of coastal land 50 to 90 km wide and 200 km long. This represents a 200% increase in coal-fired power for the entire state of Maharashtra, a state which already has the largest total installed capacity, equal to 11 GW or 13% of nationwide capacity. Such development will also promote the development of ancillaries apart from human settlements due to in-migration. This would completely transform the coast and result in a tremendous loss of biodiversity. In addition, there are aquaculture farms, mining and tourism activities. All these are likely to have cumulative impact on the biodiversity. While Untawale et al.'s 2000 report gives some idea of the biodiversity of the region, the BNHS is working on the preparation of a systematic report on the biodiversity of the coastal areas as well as an examination of the local factors that are affecting biodiversity[60].

57 Kapoor, M., K. Kohli and M. Menon 2009.India's Notified Ecologically Sensitive Areas (ESAs): The Story so far...Kalpavriksh, Delhi & WWF-India, New Delhi.

58 ENVIS, Chapter 6, Land Resources and Degradation. http://envis.maharashtra.gov.in/envis_data/pdf/soer/chapter6.pdf accessed 29 September 2012.

59 Kharland development circle. http://mahakharlanddevelopment.org/

60 Apte, D.A and V.J. Bhave, (2010). A Preliminary Report: Diversity of Coastal Marine Ecosystems of Maharashtra: Part 1.1: Rocky Shores at Ratnagiri & Rajapur District. Report by Mumbai Natural History Society. Pp 130.

9.4. Goa

Introduction: Goa is the smallest but richest state in India. It is bounded by Maharashtra to the north and Karnataka to the east and south, while the Arabian Sea forms its western boundary. The length of the coastline that was surveyed is about 200 km long. This is detailed in the table below.

Table 9.4.1: Length of coastline

Length of Coastline - Goa		
Districts	Length (Surveyed)	Length (Natmo)
South Goa	128.5	55.0
North Goa	72.3	98.0
Grand Total	**200.8**	**153.0**

Goa, along with Daman and Diu, was made into a centrally administered Union Territory of India after annexation from the Portuguese. On 30 May 1987, the Union Territory was split, and Goa was made India's twenty-fifth state, with Daman and Diu remaining a Union Territory. Goa encompasses an area of 3,702 km^2 and is part of the Konkan coast. Goa's main rivers are the Mandovi, Zuari, Terekhol, Chapora and Sal. The Mormugao harbour on the mouth of the River Zuari is one of the best natural harbours in South Asia. Zuari and Mandovi are the lifelines of Goa, with their tributaries draining 69% of its geographic area[61].

According to BMTPC's Vulnerability Atlas, Goa falls in Zone III – at moderate risk from earthquakes. The state is also at moderate risk from winds and cyclones. Apart from being vulnerable to storm surges, Goa is susceptible to tsunamis due to local coastline and estuarine topography.

A satellite-imagery-based study of shoreline change in Goa indicated that, over a 32 year period, there is large variation in depositional and erosional processes along the coast of Goa. Specifically, the study indicated that along the estuaries there is net deposition. Along the coast, deposition was observed at Morjim, Baga, Campal, Miramar and Mobor, while erosion was specifically observed at Kerim, Anjuna and Velsao[62].

Ecology and biodiversity: The coastline of Goa is characterized by continuous stretches of sandy beaches, occasionally interrupted by rocky promontories or headlands which protrude as far as 2 or 3 km into the sea. The estuarine river systems cutting across this area are dominated by tides. The coastal zone comprises an intricate system of wetlands and lowlands, tidal marshes, cultivated paddy fields, intertidal beaches, all intersected by canals, inland lakes, bays, lagoons and creeks, features which are governed by regular tides which raise or lower water levels by 2 or 3 metres daily. Sand dunes, 5,000-6,400 years old, have been the protectors of Goa's coast. Five key coastal stretches are characterized by conspicuous sand dune complexes, as follows[63]:

1. Querim - Morjim sector with pristine beaches and turtle nesting sites, including three creeks lined by mangroves and located behind sand dunes;
2. Chapora - Sinquerim belt;
3. Caranzalem - Miramar (Mandovi estuary), the most prominent dune belt within the estuaries of Goa;
4. Velsao - Mobor linear stretch being the longest strip of the most exquisite dune system of the entire coastal zone of Goa;
5. Talpona - Galgibaga strip, presently a pristine area. In addition, the coastal stretches also consist of several sandy areas and secluded coves backed by cliffs, rocky shores, headlands or promontories and wooded or bare hill slopes. Some uninhabited islands with appreciable forest cover are found off Goa.

Goa has another important feature to its landscapes – the khazan lands. The khaznam (khazan lands) are agricultural lands subject to inundation by the neighbouring river, from which they are protected by bunds. These salty low-lying flat lands were originally mangrove swamps/mudflats lying along both banks of the rivers of Goa.

61 Goa. http://en.wikipedia.org/wiki/Goa accessed 27 August 2012.

62 D'Souza, J.and G.N.Nayak. 2008. Integrated Coastal Zone Management –A Case Study from Goa. Presented at the SAARC Workshop on Coastal and Marine Risk Mitigation Plan for South Asia, Goa, 27 –28 March 2008. http://saarc-sdmc.nic.in/pdf/workshops/goa/india/INTEGRATED%20COASTAL%20ZONE%20MANAGEMENT%20A%20CASE%20STUDY%20FROM%20GOA.pdf accessed 5 July 2012.

63 Mascarenhas 1997 cited in Mascarenhas, A. Human Interference along the coast of Goa. In: Environmental problems of coastal areas in India. ed. by: Sharma, V.K.; 145-171p. Bookwell, India. http://drs.nio.org/drs/handle/2264/1320 accessed 27 Aug. 2012.

The early settlers of this place who came down from the Western Ghats reclaimed the lands by constructing mud bunds all along the river, and started cultivating them. The khaznam consist of four main components[64]: the bundh, the manas (sluice gate), the pôiim (internal water bodies) and the rice fields – elevated portions of land for cultivation. Fishing in the khazan is a secondary activity, a spin-off of land reclamation. Fishing at the manas is done using a special type of net – a bag net – which is fixed at the manas opening during the low tide when the water from the pôiim flows out into the estuary, while fishing in the pôiim is carried out using different types of nets, like gill nets, cast nets, etc. Unfortunately, Goa's agro-ecology based on khazan lands is described as being in its death throes – a victim of the development strategy followed by the state in the last few decades[65]. The bunds are in a state of disrepair, and there is entry of saline water into the fields and also into the groundwater.

Table 9.4.2: List of wetlands[66]

Wetlands of Goa							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
North Goa	84	-	-	19	-	-	36
South Goa	27	-	-	31	-	-	15
Grand Total	**111**	-	-	**50**	-	-	**51**

Table 9.4.3: Water bodies surveyed in this study

Water Bodies Goa								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North Goa	3	-	2.8	0.7	3.9	2.0	2.9	1.5
South Goa	7	1	5.3	6.5	4.5	11.1	9.6	23.7
Grand Total	**10**	**1**	**8.1**	**7.3**	**4.3**	**7.7**	**5.3**	**9.5**

Coastal settlements: Coastal Goa is densely populated. The extent of the coast occupied by settlements is given in the table.

Table 9.4.4: Settlements surveyed in this study

Settlements of Goa							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North Goa	21	24.0	8.3	33.2	23.0	24.5	17.0
South Goa	17	18.1	7.2	14.1	11.1	32.9	26.0
Grand Total	**38**	**42.1**	**15.5**	**21.0**	**15.4**	**27.5**	**20.2**

64 de Sousa, S.N. The Khaznam of Goa. http://www.nio.org/userfiles/file/events/dsouza.pdf 29 Aug. 2012.

65 Bose, I. Goa's disappearing khazan farms dying a slow death. Down to Earth. 15, June, 2007.

66 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

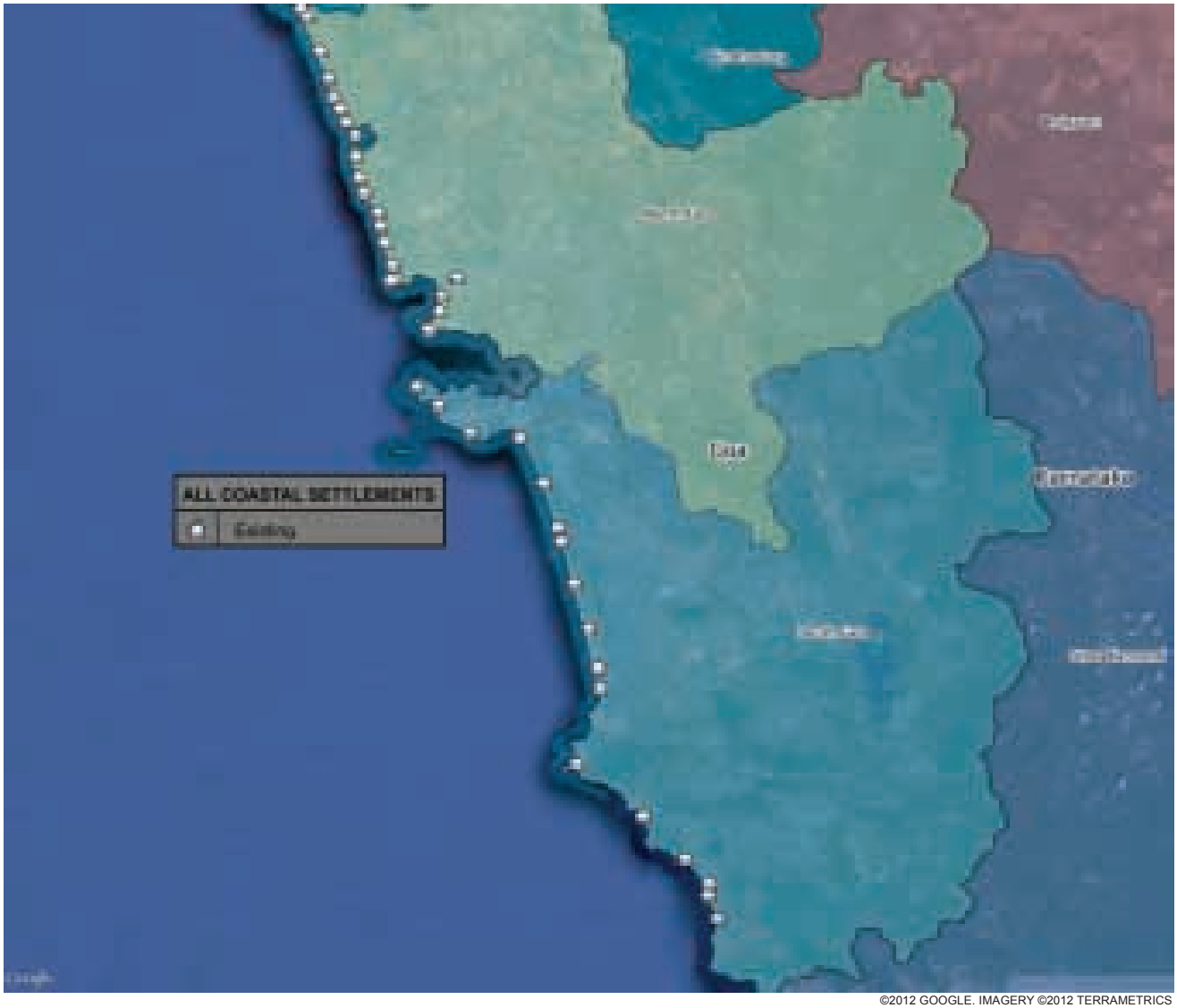


Figure 9.4.1: Settlements

Table 9.4.5: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
South Goa	23	1,388	1,363	429	6,721
North Goa	16	801	784	60	3,824
Total	39	2,189	2,147	489	10,545

Fishing: Fish, curry and rice are the staple of Goan diet, and that was also the title of the publication which is the source book on Goa. The marine fish production in Goa showed 25.3% increase (89,451 tonnes) during 2010. The marine fish production in Goa has shown a declining trend over the years, with the annual catch varying from 71,391 tonnes (2009) to 110,508 tonnes (2008). However, the 89,451 tonnes catch during 2010 was 25.3% more than the catch recorded during 2009. Increased landings during the year were due to increase in landings of rock cod and mackerel, respectively, as compared to the previous year. It was also found that while production by the mechanised sector increased by 17.1%, production by the motorised and non-mechanised sectors registered a steep decline.[67].

67 CMFRI Annual Report 2010-2011.

Fishing is a traditional activity, and as the following table shows most of the members of the fishing community belong to traditional fishing families.

PHOTO: SVEN ULSA

Figure 9.4.2: Fisherwomen on the beach

SKETCH BY PURUSHOTTAM PANDA

Figure 9.4.3: A Goan fishing village

Commercial Areas: In addition to the area occupied by settlements, the area occupied by commercial activities was mapped in this study as given below.

Table 9.4.6: Commercial areas surveyed in this study

Commercial Areas of Goa							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (NATMO) (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North Goa	38	5.9	0.8	8.2	2.2	6.0	1.7
South Goa	39	13.2	3.6	10.2	5.6	23.9	13.0
Grand Total	**77**	**19.1**	**4.4**	**9.5**	**4.4**	**12.5**	**5.7**

Tourism: It was when tourism became a major source of revenue in the 1970s that Goa's beaches began deteriorating. Most tourism activities are concentrated along the sandy stretches. In fact, it is argued that tourism has accelerated the decline of agriculture in Goa, by providing a viable alternative for the lateral transfer of investment capital, land and labour by the locals. In the fishery sector, while fishermen do not always compete with tourists for shore space, there are instances on the Goan coast where traditional fishing operations have

been constrained by lack of shore space. In some areas, fishing ports and the houses of fishermen have been displaced by resort development[68].

PHOTO: SVEN ULSA

Figure 9.4.4: Shared spaces – it is still possible - fishermen and tourists on a beach in Benaulim

Unplanned activities have resulted in haphazard development and the following major issues[69]:

- Coastal villages, once separated by open spaces, are now merging into one long continuous strip of hotels and resorts
- Existing fishing settlements are struggling for survival, as developers have bought most of the coastal strips
- North Goa has the maximum number of hotels, guesthouses, restaurants, tourism shops and beach shacks
- There is no proper access to beaches due to dense spread of structures.

The famous beaches of Goa and their degradation was what prompted Prime Minister Indira Gandhi's concern about the coastal eco-systems, when she wrote on 27 November 1981 to the state Chief Ministers expressing distress at a degradation and "misutilisation" of beaches, and that they "have to be kept clear of all activities at least up to 500 metres from water at maximum high tide"[70]. This diktat was followed in 1986 by administrative guidelines to regulate the development of beaches issued by the Union Department of Environment, eventually formalized as the Coastal Regulation Zone Notification (CRZ) in 1991, which was replaced in 2011 by the CRZ 2011.

Coastal structures: Seawalls have been recorded as the main structures in the littoral zone of Goa's coast, mainly for protecting beach resorts.

Table 9.4.7: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Goa						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
North Goa	3	2.8	3.8	2.8	-	-
South Goa	1	0.8	0.6	1.5	-	-
Grand Total	**4**	**3.6**	**1.8**	**2.3**	-	-

68 Sawkar, K., A. Noronha, A. Mascarenhas, and O.S. Chauhan, Tourism and the environment: Issues of concern in the coastal zone of Goa. In: Tourism and the environment: Case studies on Goa, India, and the Maldives. Eds. : Sawkar, K.; Noronha, L.; Mascarenhas, A.; Chauhan, O.S.; Saeed, S.; 1-19p. http://drs.nio.org/drs/handle/2264/1322 accessed 29 Aug. 2012.

69 Mascarenhas, A. 2002. Fish curry and rice: A source book on Goa, its ecology and life-style. 4th ed.. Ed. by: Alvares, C., p.218. The Goa Foundation; Mapusa, Goa; India. http://drs.nio.org/drs/handle/2264/1417.

70 Archives, Mumbai Environmental Action Group, c.f. A. Rosencranz and Shyam Diwan, Environmental Law and Policy in India, (2nd ed., OUP: New Delhi, 2002), p. 477.

Figure 9.4.5: Structures

Ports and harbours: Mormugao is a major port (since 1964). It is an open type harbour protected by a breakwater and a mole built from the outer end of the breakwater and running parallel to the quay. The harbour is also protected from the south west monsoon as it has been constructed on the leeward side of Mormugao Headland[71]. During the financial year 2011-2012 the port handled traffic of 39 million tonnes, 7% of the total traffic handled by all major ports together. A large portion of the traffic was iron ore, which was not surprising as it caters to about 40% of the iron ore handled through the country. In addition to Mormugao, there are minor ports at Panaji, Tiracol, Chapora, Betul and Talpona, out of which Panaji is the main operative port. Inland transport via the state's waterways is important for bringing iron ore from the hinterland to the coast for export.

Table 9.4.8: Ports surveyed in this study

Ports & Harbours of Goa							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North Goa	2	0.6	-	0.8	0.1	0.6	0.1
South Goa	4	3.9	0.8	3.1	1.2	7.2	2.8
Grand Total	**6**	**4.5**	**0.8**	**2.3**	**0.8**	**3.0**	**1.1**

71 Mormugao Port Trust. http://www.mptgoa.com/location.php

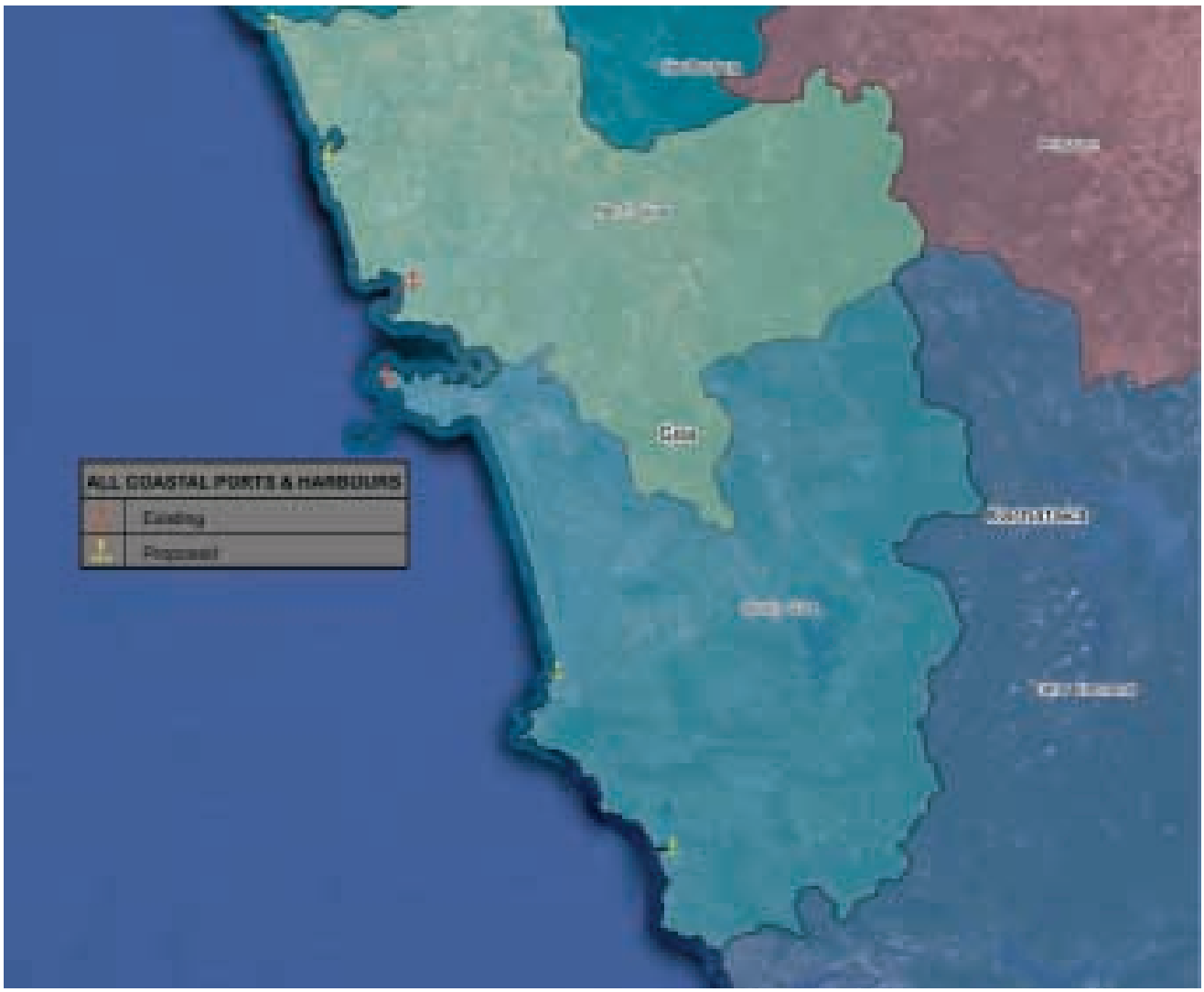


Figure 9.4.6: Ports

Table 9.4.9: Proposed ports

Proposed Ports		
No. of ports State	**District**	**Total**
Goa		
	North Goa	2
	South Goa	2
Total		**4**

Thermal Power Plants: Goa's gas power station is located at Zuarinagar. The 48 MW existing capacity of the plant is to be expanded by adding 52 MW. The expansion project is to be set up in existing plant premises, which include 12.8257 ha of land. Gas will be obtained from Dabhol (Maharashtra) through the Dabhol-Bangalore pipeline. The company is also planning to switch its existing plant run by naptha to natural gas[72].

Table 9.4.10: Coastal thermal power plants

Existing Power Plants - Coastal			
Sl.No	District	Type	Project Name
1	Goa	Gas and liquid fuel	Goa Gas Power Station

72 Goa Thermal Projects. http://thermalpower.industry-focus.net/goa-thermal-projects.html accessed 24 Aug. 2012.

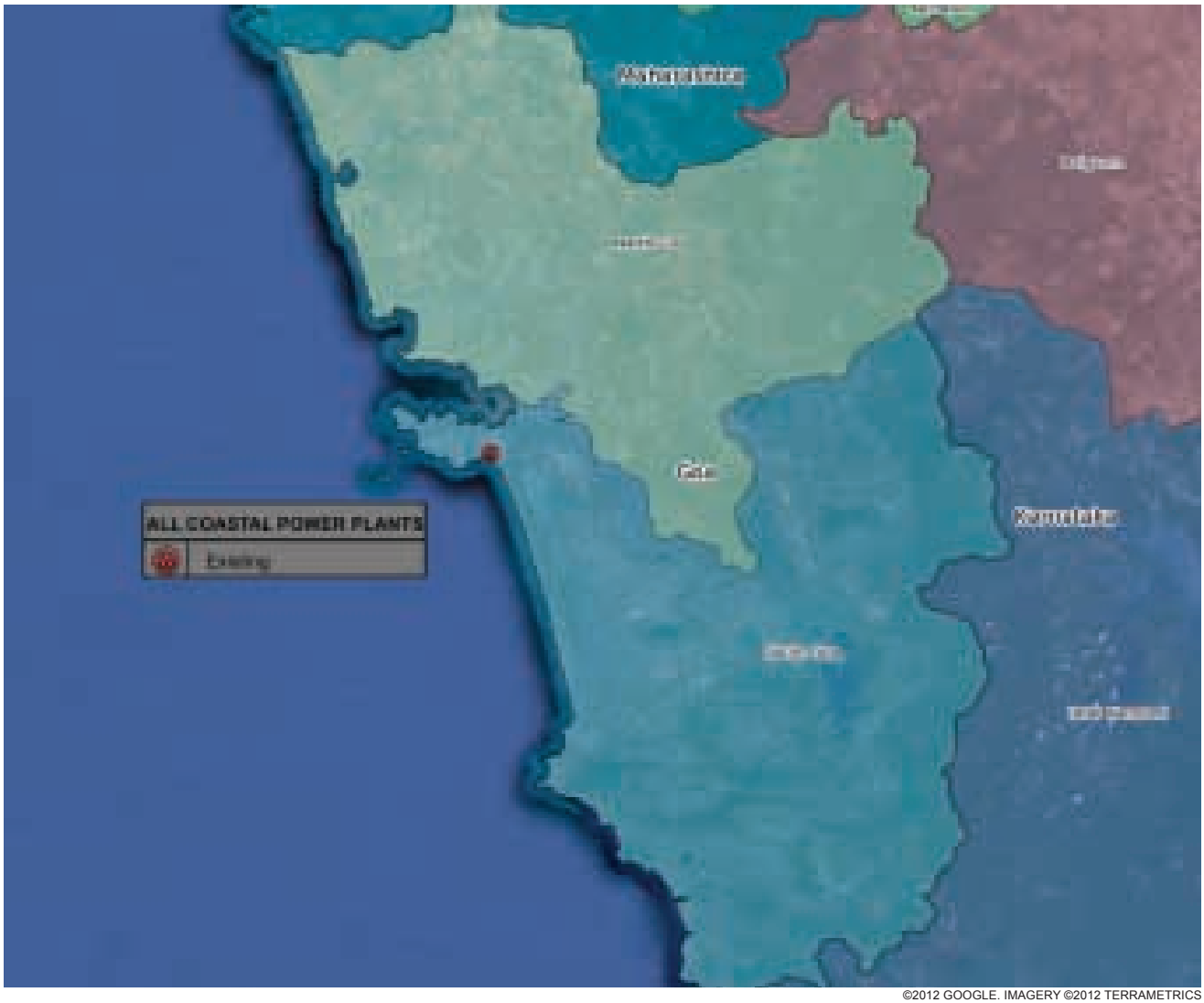


Figure 9.4.7: Power Plants

Special Economic Zones: The Goa government scrapped the SEZ policy in 2008 after a string of protests by civil society. Initially 15 SEZs were proposed, of which 3 were denotified in 2010 after several irregularities were pointed out in land allocation[73]. Recently, a state minister said that setting up seven Special Economic Zones (SEZs) in Goa would have resulted in immigration and doubled the population of the state and threatened its unique culture; also that the power and water that would be required for large scale industrialization of the state was not available[74].

Challenges/issues in the coastal zone: Goa's main problems in the coastal areas are sand mining, erosion, construction and pollution. Sand dunes are being razed, leveled or flattened to make way for hotels, resorts and other structures, resulting in irreversible damage to the dunes. In addition, a negative sand budget has been created which has resulted in erosion, clearly observed in Palolem. Dune removal has also resulted in the entry of saline water into paddy fields, apart from storm surges and inundations[75]. 59 species of dune plants have been reported from Goa[76]. Native plant species are prevented from colonising because of the preference for lawn grass and exotic shrubs for landscaping, but it is the native dune vegetation that can stabilize the dunes, as it acts as a sand binder. It has also been found that buildings also change the location of accretion and scour on beaches and dunes.

73 TNN. Commerce minister moves to denotify SEZs in Goa. 3 Dec. 2010, http://articles.timesofindia.indiatimes.com/2010-12-03/india-business/28226315_1_goa-sezs-denotify-sez-promoters accessed 27 Aug. 2012+

74 SEZs would have doubled Goa's population: Minister. http://zeenews.india.com/news/goa/sezs-would-have-doubled-goa-s-population-minister_789402.html accessed 27 Aug. 2012.

75 Mascarenhas, A. A Report on coastal sand dune ecosystems of Goa: significance, uses and anthropogenic impacts. NIO, Goa, March 1998.

76 Desai 1995 quoted in Mascarenhas, 1998.

At Candolim beach in North Goa, erosion had been caused by a 240 m long ship running aground. This had resulted in a change in the direction of waves approaching the shore. A geotube was installed in 2009 but soon sank in the sand. Erosion continued. A second line was fixed seaward around October 2009. During the 2010 monsoon the waves overshot the tubes. In 2008-09, the NIO had estimated that Sinquerim had lost around 80,000 m^2 of its beach[77]. In June 2012, the grounded ship was removed and the beach is reportedly building up again[78].

In the **CRZ 2011 Notification**, Goa comes under v) A) Areas requiring special consideration for the purpose of protecting the critical coastal environment and the difficulties faced by local communities. According to the notification, "In view of the peculiar circumstances of the State of Goa, including past history and other developments, the specific activities shall be regulated and various measures shall be undertaken as follows:-

(i) the Government of Goa shall notify the fishing villages wherein all foreshore facilities required for fishing and fishery-allied activities such as traditional fish processing yards, boat building or repair yards, net mending yards, ice plants, ice storage, auction hall, jetties may be permitted by Grama Panchayat in the CRZ area;

(ii) reconstruction, repair works of the structures of local communities including fishermen community shall be permissible in CRZ;

(iii) purely temporary and seasonal structures customarily put up between the months of September to May;

(iv) the eco-sensitive low lying areas which are influenced by tidal action known as khazan lands shall be mapped;

(v) the mangroves along such as khazan land shall be protected and a management plan for the khazan land prepared and no developmental activities shall be permitted in the khazan land;

(vi) sand dunes, beach stretches along the bays and creeks shall be surveyed and mapped. No activity shall be permitted on such sand dune areas;

(vii) the beaches such as Mandrem, Morjim, Galgiba and Agonda have been designated as turtle nesting sites and protected under the Wildlife Protection Act, 1972, and these areas shall be surveyed and management plan prepared for protection of these turtle nesting sites;

(viii) no developmental activities shall be permitted in the turtle breeding areas referred to in sub-paragraph (vii)."

9.5. Karnataka

Introduction: Karnataka is the eighth largest Indian state by area. The length of the coastline that was surveyed is about 325 km and is detailed in the table below.

Table 9.5.1: Length of coastline

Length of Coastline - Karnataka		
Districts	Length (Surveyed)	Length (Natmo)
Uttara Kannada	175.0	153.0
Udupi	111.0	100.0
Dakshina Kannada	39.1	40.0
Grand Total	**325.1**	**293.0**

South of the small state of Goa, its two major river systems are Krishna and Cauvery which, along with their tributaries, flow through the state. The coastline is highly indented with numerous river mouths, lagoons, bays, creeks, promontories, cliffs, spits, sand dunes and long beaches. The shelf off the coast of Karnataka

77 Geo-tubes a Rs 6 crore loss: NIO scientist. 12 April 2011. http://articles.timesofindia.indiatimes.com/2011-04-12/goa/29409427_1_geo-tubes-sinquerim-beach-sandeep-nadkarni

78 Pereira, A. Princess is history before turning 13. The Times of India, 3 June 2012. http://articles.timesofindia.indiatimes.com/2012-06-03/goa/32005403_1_candolim-beach-hanumant-parsekar-arihant-ship-breakers accessed 10 Sep. 2012.

has an average width of 80 km and the depth of shelf break is 90-120 metres. There are a few islands off the coast. The important estuaries include the Netravati-Gurpur, Gangolli, Hangarkatta, Sharavati, Aganashini, Gangavali and Kalinadi. There are 90 beaches with varying aesthetic potential, of 22 beaches are classified as unfit for use due to coastal erosion, human settlements and activities linked to ports and harbours, industries and fisheries[79].

Karnataka's State of the Environment 2003 has a detailed chapter on Coastal Zone Management[80]. According to this report, there are 22 urban agglomerations and 1,044 villages on the coast. Karnataka's coastal zone management authority has a website (http://www.ksczma.kar.nic.in/) where the CZM maps are available. According to the chapter on coastal zone management, on-the-ground reference pillars have been established all along the coast at a distance of 250 metres. The pillars are numbered, and inscribed with details pertaining to the shortest distance to the HTL and the direction of the pillar from the HTL. The Action Plan described in the report calls for restriction in the construction of seawalls and breakwaters except in areas where such structures are required to protect vital infrastructure, and suggests that construction of such structures should be subject to comprehensive environmental impact assessment. It also says that environmental clearance for projects in the coastal zone should be given only after considering the project-based EIA finding in the background of the carrying capacity of the region or based on strategic EIA.

Ecology and biodiversity: The first comprehensive study of floral biodiversity along the Karnataka coast carried out in 2005-06 found 53 phytoplankton, 78 seaweed and 2 seagrass species from estuarine, intertidal, open sea and island ecosystems[81]. Phytoplankton, dominated by diatoms, were found to be more diverse in estuarine areas than in sea and intertidal regions. The 78 species of seaweeds belonged to 52 genera and 28 families.

Table 9.5.2: List of wetlands[82]

Wetlands of Karnataka							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Dakshin Kannada	10	-	-	14	-	-	9
Udupi	78	6	1	12	-	-	23
Uttar Kannada	52	7	1	37	-	-	65
Grand Total	**140**	**13**	**2**	**63**	-	-	**97**

Table 9.5.3: Water bodies surveyed in this study

Water Bodies of Karnataka								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Udupi	6	1	20.9	5.9	18.8	10.7	20.9	11.8
Dakshina Kannada	3	-	5.8	1.9	14.8	9.5	14.4	9.3
Uttara Kannada	12	1	10.1	3.1	5.8	3.5	6.6	4.0
Grand Total	**21**	**2**	**36.8**	**10.9**	**11.3**	**6.7**	**12.6**	**7.4**

79 Karnataka State of the Environment 2003. Coastal Zone Management.

80 Ibid.

81 P. Kaladharan, P. U. Zacharia and K. Vijayakumaran. Coastal and marine floral biodiversity along the Karnataka coast J. Mar. Biol. Ass. India, 53 (1) : 121 - 129, 2011.

82 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Coastal settlements: The table below gives information about coastal settlements within the 500m zone as mapped by this study.

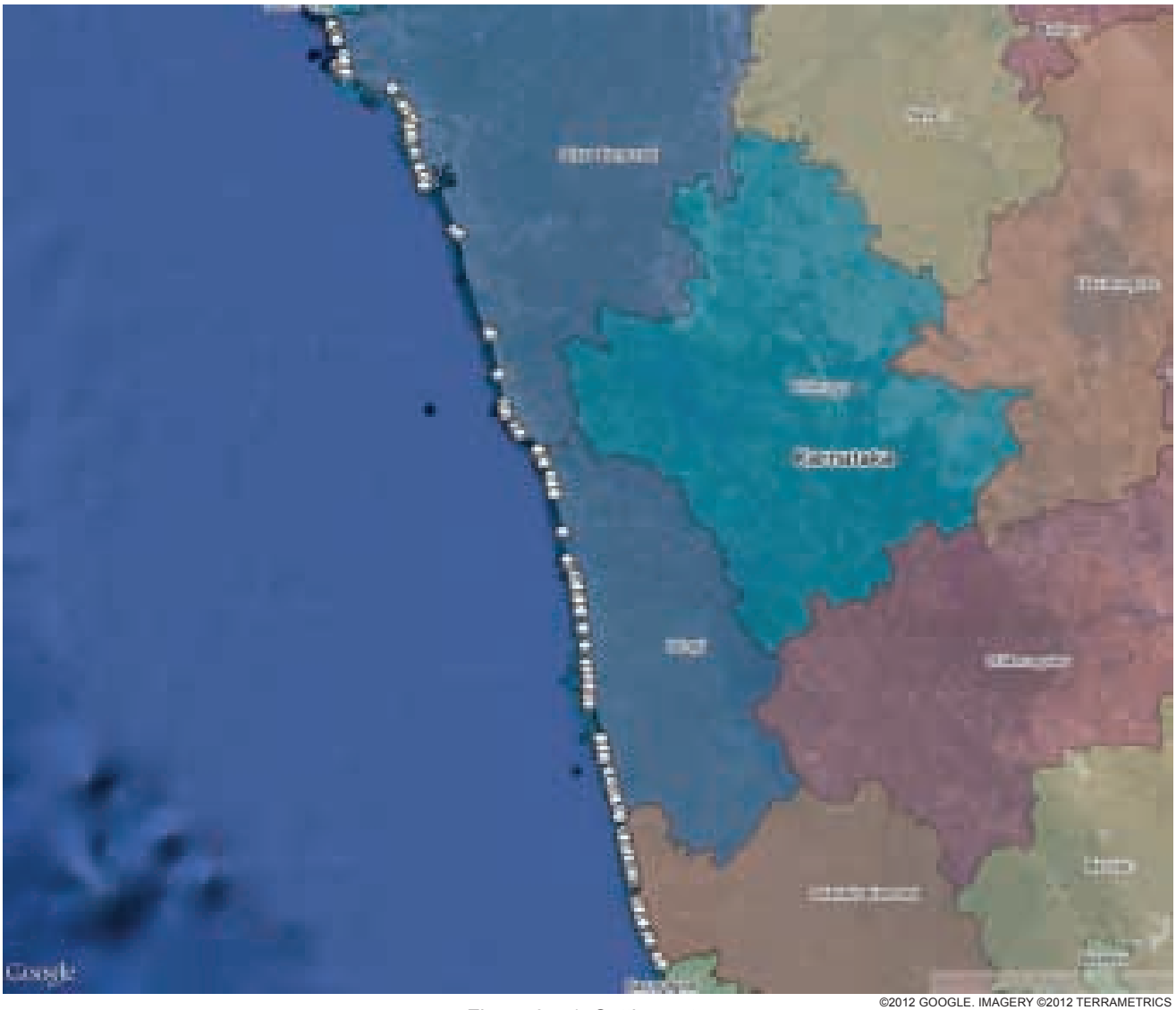


Figure 9.5.1: Settlements

Table 9.5.4: Settlements surveyed in this study

Settlements of Karnataka							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Udupi	36	44.9	13.2	40.5	23.7	44.9	26.3
Dakshina Kannada	20	19.6	5.6	50.2	28.9	49.1	28.2
Uttara Kannada	41	36.0	10.9	20.6	12.4	23.6	14.2
Grand Total	**97**	**100.6**	**29.7**	**31.0**	**18.3**	**34.3**	**20.3**

The population of the fishing community according to the latest CMFRI census is given in the table below.

Table 9.5.5: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
Dakshina Kannada	17	4,570	3,941	1,485	27,281
Udipi	41	9,907	9,030	7,650	61,658
Uttara Kannada	86	16,236	15,562	14,489	78,490
Total	144	30,713	28,533	23,624	167,429

Fishing: In 2010-2011, Karnataka recorded an all-time high of 332,311 tonnes of marine fish landed. This was attributed to the increase in the landings of molluscs, especially cephalopods (118%) and pelagics (ribbonfish (73.7%), carangids (51.1%) and mackerel (41.8%), as compared to the previous year. The mechanized, motorized and non-mechanized sectors contributed 90.7%, 8.1% and 1.2% respectively to the catch. While production by mechanized sector increased by 27.4%, the production by motorized and non-mechanized sectors registered a steep decline[83]. Mangalore coast is well known for its multi-species and multi-gear fisheries, and the fishery and oceanographic features of this region are a true representation of the Malabar upwelling system. Field and satellite-derived oceanographic data have shown that coastal upwelling occurs during July-September, with a peak in August, resulting in high nutrient concentrations and biological productivity along the coast. Nearly 70% of the pelagic fish catch, dominated by oil sardine and mackerel, was obtained during September-December, during or immediately after the upwelling season[84].

PHOTO: SUDARSHAN RODRIGUEZ

Figure 9.5.2 Karwar port next to fishing hamlet and harbour

83 CMFRI Annual Report 2010-2011.

84 Krishnakumar, P. K. and G. S. Bhat, Fisheries Oceanography 17:1, 45–60, 2008 http://www.cmfri.org.in/latest-research-findings.html

Commercial Areas: In addition to settlements, space used for commercial activities on the coast was also mapped.

Table 9.5.6: Commercial areas surveyed in this study

Commercial Areas of Karnataka							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (NATMO) (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Udupi	9	2.4	0.2	2.1	0.3	2.4	0.3
Dakshina Kannada	14	6.1	1.2	15.6	5.9	15.3	5.8
Uttara Kannada	29	8.2	0.7	4.7	0.8	5.3	0.9
Grand Total	**52**	**16.6**	**2.0**	**5.1**	**1.2**	**5.7**	**1.4**

Shore line change: Of the 325 km of coastline, about 75% is sandy beaches, 11% is rocky coast and 14% mud flats. As of January 2009, according to a study which indicated the coast of Karnataka to be 280 km long, 249.56 km of the coast was affected by erosion and 57 km had been protected. This means that 89% of the coast was facing erosion[85]. The coast is subject to erosion of beaches at river/estuary mouths as well as tidal reaches of rivers. Siltation is severe in all ports, especially at the New Mangalore Port, which requires heavy annual maintenance dredging. The siltation in Karwar port is relatively low. Anti sea-erosion activities have been carried out since the 1970s. Though it is known that the cause of the problem is site-specific and non-uniform, the only type of intervention is seawalls. According to Subashchandran et al[86], "the erosion problems in Dakshina Kannada and Udupi districts are more severe than in Uttara Kannada, which has a greater proportion of rocky shores. About 28% of the total stretch of coastline in the Dakshina Kannada-Udupi region is considered "critical" from the point of erosion, compared to 8% in Uttara Kannada. Coastal erosion and submergence of land have been reported at Ankola, Gokarna, Honavar, Bhatkal, Marvante, Malpe, Mulur, Mangalore, etc. Total annual losses in Karnataka, in the form of loss of land and property due to sea erosion, are estimated to be about Rs.31.28 crores." The coastal zone of Karnataka comes under Zone III Moderate Damage Risk Zone for earthquakes and under Moderate Damage Risk Zone for wind and cyclones according to the BMTPC Vulnerability Atlas.

Coastal structures: Structures in the littoral zone have been identified mainly as rubble-mounded seawalls and groynes. A summary of the different structures mapped in this project is given in the table below.

Table 9.5.7: Structures surveyed in this study

Structures of Karnataka									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Dakshin Kannad	3	-	-	-	-	-	-	-	3
Udipi	2	-	-	-	-	-	-	-	2
Uttar Kannad	-	-	-	-	-	-	1	-	1
Total Nos.	**5**	-	-	-	-	-	**1**	-	**6**
Total length of structures (km)	3.2	-	-	-	-	-	0.1	-	3.3

85 The total length of the coastline according to this calculation works out to be 306.33, which is 26 km more than given by the NHO but about 14 km less than given by others.

86 Subash Chandran, M.D., G.R. Rao, Prakash Mesta, D.M. Vishnu and T.V. Ramachandra. Green Walls for Karnataka's coast. ENVIS Technical Report: 34, February 2012.

Figure 9.5.3: Structures

Table 9.5.8: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Karnataka						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Dakshina Kannada	4	6.7	17.1	16.8	1	0.1
Udupi	11	5.5	4.9	5.5	2	0.3
Uttara Kannada	5	4.7	2.7	3.1	7	6.6
Grand Total	**20**	**16.8**	**5.2**	**5.7**	**10**	**7.0**

Ports and harbours: Karnataka has one major port at Mangalore and nine minor ports at Karwar, Belikund, Tadri, Honavar, Bhatkal, Kundapur, Hangarkatta, Malpe and Old Mangalore. There are 110 fish landing centres. The major port located at Mangalore is an all-weather port situated at Panambur, towards the north of the confluence of Gurupur river to the Arabian Sea. It ranks as India's ninth largest port in terms of cargo handling, as it handles 75% of India's coffee exports and the bulk of its cashew nuts. Major commodities exported through this

port are iron ore concentrates & pellets, POL products, granite stone and containerized cargo, etc. Major imports include crude and POL products, LPG, wood pulp, timber logs, finished fertilizers, liquid ammonia, phosphoric acid, other liquid chemicals and containerized cargo.

Ten ports in the state are to be handed over to the private sector through the Marine Board for development under public-private partnership. The ports in the first phase are Karwar, Tadadi and Belekeri followed by Malpe, Hangarakatte and Gangolli[87].

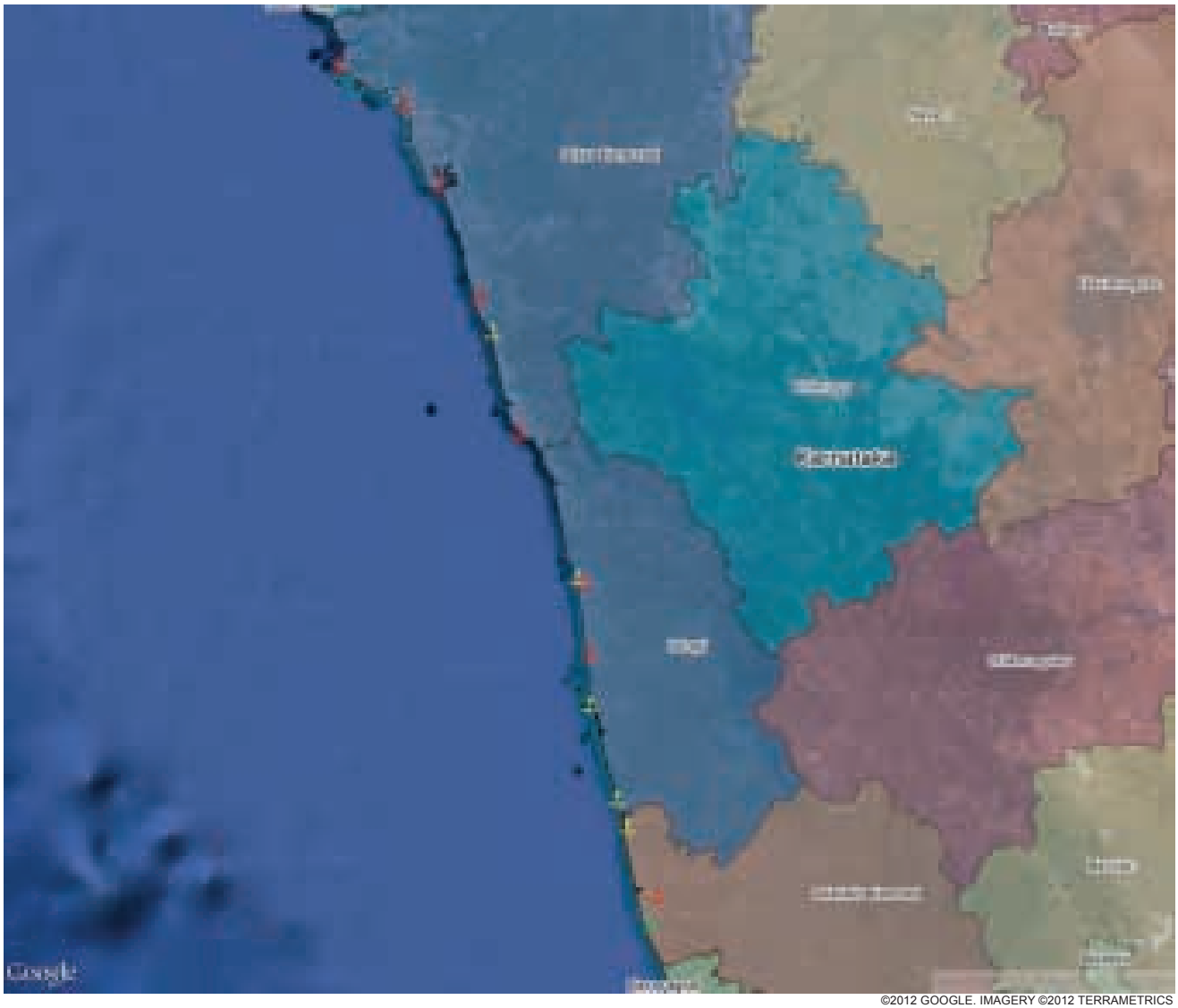


Figure 9.5.4: Ports

Project Sea Bird was the code name for the greenfield naval base (INS Kadamba) on the west coast located in Karwar. Spread over an area of 45 km^2 (11,000 acres) and along 23 km of coastline, the total cost of this project is estimated to be US$ 3 billion[88]. The main features of the project are a large basin protected by 5.5 km of breakwaters, reclaimed areas for development of ship-lift and berthing facilities, aircraft carrier berthing facilities, and large onshore developments with residential complexes and administrative facilities. The first phase of construction of the base was completed in 2005. Development of Phase II commenced in 2011. INS Kadamba is the third largest Indian naval base.

87 Rs 700-cr action plan to check sea erosion. Deccan Heraald, June 7. http://www.deccanherald.com/content/74080/rs-700-cr-action-plan.html

88 INS Kadamba. http://en.wikipedia.org/wiki/INS_Kadamba; Project Sea-bird: http://www.haskoningindia.co.in/projects/Seabird.html accessed 31 Aug. 2012.

The length of the coastline and the space in the littoral zone occupied by ports is given in the table below.

Table 9.5.9: Ports surveyed in this study

Ports & Harbours of Karnataka							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Dakshina Kannada	2	1.3	0.6	3.2	3.0	3.2	3.0
Udupi	3	2.3	0.6	2.0	1.1	2.3	1.2
Uttara Kannada	5	2.6	0.5	1.5	0.6	1.7	0.7
Grand Total	**10**	**6.1**	**1.7**	**1.9**	**1.1**	**2.1**	**1.2**

Table 9.5.10: Proposed ports

Proposed ports		
No. of ports State	**District**	**Total**
Karnataka	**Udupi**	5
Total		**5**

Only one thermal power plant is presently located in a coastal district, though three more are coming up in coastal districts.

Figure 9.5.5: Power plants

Table 9.5.11: Coastal thermal power plants

Existing power plants - coastal				
Sl.No	State	Type	District	Project Name
1	Karnataka	Thermal-coal	Udupi	Udupi Thermal Power Plant

In addition to the above, one proposed thermal power plant is to be located more than 10 km from the coast.

Table 9.5.12: Proposed thermal power plants

Power plants - upcoming					
	Fuel	**District**	**Village**	**Company**	**Ownership**
1	Coal	Uttara Kannada	Hankon	IND- Bharat Power (Karwar) Ltd	private
2	Coal	Uttara Kannada	Padubidri	Lanco - Udupi Power Corporation Ltd.	Private
3	Gas	Dakshina Kannada	Panambur Taluk	GMR Energy Ltd.	private

SEZ: In June 2008, the state government approved more than 2,400 hectares of land for setting up 45 special economic zones (SEZs) in Karnataka. This is expected to attract an investment of Rs. 24,000 crore. A total of 6,244.4 hectares is needed for SEZs in Karnataka[89]. The information on the website says that the land is to be acquired directly from the farmers, and if more than 50% of the farmers in any area are not willing to go ahead with the project it would be scrapped. Most recently, the Karnataka High Court has ruled that the Mangalore Special Economic Zone (MSEZ) Ltd is a public authority and thereby bound to dispense information under the Right to Information Act, 2005. Land acquisition has been a problem for MSEZ, and consequently had been facing a number of RTI enquiries about the steps taken to rehabilitate displaced families and usage of land area, among others[90].

Challenges/issues in the coastal zone: Pollution levels off the Dakshina Kannada coast are high. Various types of small, medium and large industries located near Mangalore discharge their effluents directly into the coastal water off Kulai. Available information indicates that Mangalore Refineries and Petrochemical Ltd (MRPL) discharges 7,200 m^3/d; BASF India Ltd discharges 3,600 m^3/d north of the harbour; and Mangalore Chemicals & Fertilizers (MCF) discharges 13,000 m^3/d south of the harbour[91]. However, more than pollution problems, it is erosion that is of greatest concern on Karnataka's coast. Studies on erosion/accretion over long term periods (30 years) have indicated that erosion is not continuous but occurs in isolated stretches. Comparatively high erosion has been observed at river mouths[92].

A study[93] on the Karnataka coast carried out 12 years ago showed that the Dakshina Kannada coast was undergoing extensive industrialization, which began with the establishment of Mangalore Port in the 1970s; petrochemical industries and power plants were important in the list. Uttara Kanada at that time was comparatively free of heavy industries but tourism and industrial aquaculture were on the rise. Land acquisition had completely changed the livelihood of the locals, earlier dependent on agriculture and fisheries. Privatization of coastal land for resorts was another issue that was highlighted.

Current reports indicate investments of more than Rs. 17,000 crore in biotechnology, agriculture, petroleum & petrochemicals, tourism and service sectors in Karnataka. The next growth engine for the state is seen to be the coastal region, with the government planning steps to improve the infrastructure facilities in the region, including road and rail connectivity. The plans include Ankola-Hubli and Talaguppa-Honnavar railway lines, widening of Shirady-Agumbe, Charmady and Sampaje roads, installation of power lines, and development of an IT hub on the coast[94].

89 Special Economic Zones in Karnataka. http://www.karnataka.com/watch/sez/ accessed 17 Sept. 2012.

90 The Hindu, High Court orders MSEZ to respond to RTI queries. Mangalore, 31 August 2012. http://www.thehindu.com/news/cities/Mangalore/article3843708.ece

91 Shirodkar, P.V., U.K. Pradhan and P. Vethamony. Impact of Water Quality Changes on Harbour Environment Due to Port Activities along the West Coast of India. Second International Conference on Coastal Zone Engineering and Management (Arabian Coast 2010), 1-3 November 2010, Muscat, Oman ISSN: 2219-3596.

92 Vinayaraj, P., Glejin Johnson, G. Udhaba Dora, C. Sajiv Philip, V. Sanil Kumar and R. Gowthaman. Quantitative Estimation of Coastal Changes along Selected Locations of Karnataka, India: A GIS and Remote Sensing Approach. International Journal of Geosciences, 2011, 2, ***385-393*** doi:10.4236/ijg.2011.24041 Published Online November 2011 (http://www.SciRP.org/journal/ijg).

93 Equations, 2000. Karnataka Coast - A case for better protection. http://www.scribd.com/doc/34573308/Karnataka-Coast-A-Case-for-Better-Protection accessed 31 Aug. 2012.

94 Karnataka's coastal region awash with Rs. 17,000 crore investment. 5 Jan 2012. http://www.dnaindia.com/bangalore/report_karnataka-s-coastal-region-awash-with-rs17000-crore-investment_1633754 accessed 31 Aug. 2012.

9.6. Kerala

Introduction: South of Karnataka on the west coast of India is Kerala. The state, often referred to as 'God's Own Country', is an important destination for both domestic and international tourists. It is known for its backwaters, beaches and Ayurvedic treatment. The state has an area of 38,863 km^2 and a coastline that is about 593 km long according to the survey conducted during this study and detailed in the table below.

Table 9.6.1: Length of coastline

Length of Coastline - Kerala		
Districts	Length (Surveyed)	Length (Natmo)
Trivandrum	70.2	79.0
Thrissur	58.7	61.0
Malappuram	61.0	56.0
Kozhikode	68.0	58.0
Kollam	50.6	32.0
Kasaragod	73.5	97.0
Kannur	83.8	53.0
Ernakulam	48.3	42.0
Alapuzha	79.2	86.0
Grand Total	**593.3**	**564.0**

The width of the state varies between 11 and 121 km. Kerala's coastal belt, wedged between the Western Ghats and the Arabian Sea, is relatively flat and crisscrossed by a network of interconnected brackish canals, lakes, estuaries and rivers, known as the Kerala Backwaters. Lake Vembanad, Kerala's largest body of water, dominates the backwaters; it lies between Alappuzha and Kochi and is more than 200 km^2. Kerala has 44 rivers, which are short and swift flowing without deltas.

According to studies by the NHO (Table 8.7), which indicate that Kerala's coast is about 570 km long, 80% of the shoreline is sandy, 5% is rocky and 15% is mud flats.

Ecology and biodiversity: Kerala's coast has extensive wetlands associated with it. The most famous is the Ramsar site of Vembanad Lake. The Port of Kochi is located around two islands (the Willingdon Island and Vallarpadam) in a portion of this lake known as the Kochi Lake. It lies at sea level, and is separated from the Arabian Sea by a narrow barrier island.

Table 9.6.2: List of wetlands[95]

Wetlands of Kerala							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Alappuzha	-	14	16	5	-	-	-
Ernakulam	-	-	8	4	-	-	-
Kannur	-	-	2	20	-	-	-
Kasaragod	-	-	1	14	-	-	-
Kollam	-	-	13	-	-	-	-
Kottayam	-	-	3	-	-	-	-
Kozhikode	-	5	-	24	-	-	-
Malappuram	-	-	1	12	-	-	-
Thrissur	-	-	1	7	-	-	-
Trivandrum	-	-	19	15	-	-	-
Grand Total	**-**	**19**	**64**	**101**	**-**	**-**	**-**

95 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Wetlands of Kerala are subject to acute pressure in the form of development activities. Infrastructure development has led to the fragmentation of habitats and destroyed extensive areas of coastal vegetation. Rapid urbanization has been at the cost of mangroves. Overall, the major issues threatening wetlands are related to pollution, eutrophication, encroachment, reclamation, mining and biodiversity loss.

Table 9.6.3: Water bodies surveyed in this study

Water Bodies of Kerala								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Alappuzha	27	-	26.4	2.3	33.3	5.7	30.7	5.3
Ernakulam	4	1	12.9	4.2	26.8	17.4	30.8	20.0
Kannur	1	3	7.8	2.0	9.3	4.8	14.7	7.6
Kasaragod	10	1	19.9	4.5	27.1	12.2	20.5	9.3
Kollam	7	-	26.0	4.4	51.3	17.3	81.1	27.4
Kozhikode	4	1	8.1	2.0	11.3	5.6	14.0	7.0
Malappuram	3	-	5.2	1.4	8.5	4.7	9.3	5.1
Thrissur	2	-	6.1	0.8	10.4	2.8	10.0	2.7
Trivandrum	9	-	9.8	1.2	14.0	3.5	12.5	3.1
Grand Total	**67**	**6**	**122.2**	**22.8**	**20.5**	**7.7**	**21.7**	**8.1**

Coastal settlements: The table below gives details of the space occupied by settlements in the littoral zone as mapped by this project.

Table 9.6.4: Settlements surveyed in this study

Settlements of Kerala							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ernakulam	23	16.8	4.7	34.7	19.3	40.0	22.2
Kollam	40	25.3	6.7	50.1	26.5	79.2	41.9
Kannur	24	20.3	8.7	24.3	20.9	38.4	33.0
Kasaragod	16	26.7	8.1	36.4	22.0	27.6	16.7
Kozhikode	34	38.7	11.3	56.8	33.2	66.6	38.9
Malappuram	20	13.7	4.9	22.4	15.9	24.5	17.3
Trivandrum	48	34.1	10.6	48.5	30.1	43.1	26.7
Alappuzha	35	31.8	10.0	40.2	25.3	37.0	23.3
Thrissur	14	11.2	3.5	19.1	12.1	18.4	11.6
Grand Total	**254**	**218.6**	**68.4**	**36.9**	**23.1**	**38.8**	**24.3**

Table 9.6.5: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
Trivandrum	42	33,340	32,859	19,377	146,326
Kollam	26	12,488	12,273	8,488	63,300
Alappuzha	30	20,278	20,024	10,244	92,033
Ernakulam	21	9,318	8,898	4,405	42,083
Thrissur	18	5,448	4,880	3,163	27,572
Malappuram	23	14,940	14,747	6,760	98,120
Kozhikode	35	14,157	13,983	7,452	82,129
Kannur	11	4,331	4,157	2,315	27,949
Kasargod	16	4,637	4,500	3,255	30,653
Total Kerala	**222**	**118,937**	**116,321**	**65,459**	**610,165**

Fishing: The total marine fish catch along the Kerala coast was 530,000 tonnes during 2010, which was 2.39% more than that of 2009 (518,000 tonnes). The overall increase recorded was due to the increased landing of small pelagics. Among 57 important groups of fishes monitored, 38 showed a decline while 19 projected an increase in yield. The contributions by mechanized, motorized and artisanal sectors were 62%, 37% and 1% respectively. The fisher population given below has been extracted from the 2010 CMFRI census.

Commercial Areas: Commercial spaces were also mapped in the 500 m zone from the shoreline, presented in the table below.

Table 9.6.6: Commercial areas surveyed in this study

Commercial Areas of Kerala							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Ernakulam	27	16.8	9.1	34.7	37.8	39.9	43.5
Kannur	22	8.0	6.7	9.6	16.0	15.1	25.3
Kasaragod	20	5.8	0.6	7.9	1.6	6.0	1.2
Kollam	16	5.4	0.6	10.7	2.4	17.0	3.8
Kozhikode	21	4.0	0.5	5.9	1.5	6.9	1.8
Malappuram	18	3.7	0.4	6.1	1.3	6.6	1.4
Thrissur	19	2.5	0.3	4.2	0.9	4.1	0.9
Trivandrum	51	23.8	3.5	33.9	10.0	30.1	8.8
Alappuzha	22	3.4	0.3	4.3	0.8	4.0	0.7
Grand Total	**216**	**73.5**	**22.0**	**12.4**	**7.4**	**13.0**	**7.8**

In addition to fishing, tourism is an important activity in Kerala. The most popular tourist attractions in the state are the beaches, backwaters and hill stations. Major beaches are at Kovalam, Varkala, Kappad, Muzhappilangad and Bekal. In 2011, tourist inflow into Kerala is supposed to have crossed the 10 million mark; Kochi ranks first in the total number of domestic and international tourists in Kerala. However, Kerala's beach tourism industry is under threat due to extensive beach erosion, including at the famed beaches of Kovalam.

Shoreline change: The length of coast affected by erosion is about 480 km. According to the National Assessment of Shoreline Change[96] which reports that Kerala's coast is 570 km long, 53% or 309 km of Kerala's coast was artificial (with seawalls). 0.4% of the coast was being highly eroded whereas 4.9% of the coast was described as highly accreting. There were 106 groynes and 25 breakwaters. The study concluded that only 37% of the coast is natural (without intervention).

Due to the high erosion of the coast near Kovalam, a well-known beach near Trivandrum, the state capital, a multipurpose artificial underwater reef was installed off the Kovalam beach between the lighthouse and the Edakkal rocks off the beach; it has been able to protect the beach by mimicking natural reef structures and working in concert with nature. The 100 m long reef has 28 giant geo-textile bags (with a life of over 40 years) filled with sand. It has been placed at a depth of 2 m to 4 m so that the reef will block breakers more than one-metre high, leaving only small waves to wash ashore.[97]

PHOTO: SVEN ULSA

Figure 9.6.1 Kovalam beach

Along with the existing threat of beach erosion is the construction of the Vizhinjam terminal, located close to Kovalam. The South Kerala Hoteliers' Forum (SKHF), representing the interests of the tourism industry in the area, believe that the coming of the port would mean the immediate closure of 31 big and small tourist resorts stretching from Vizhinjam to Adimalathura 2.3 km away, since breakwaters to be constructed for the shipping channel would stretch from Vizhinjam to even beyond Adimalathura, parallel to the coast. Quoting experts, the forum said the dynamics of the sea currents along the southern stretch of the Kerala coast were such that there would be erosion of the coast to the north of any breakwater constructed into the sea and accretion of sand along the stretch lying to the south. This was the experience noticed in the case of all the minor breakwaters constructed along the south Kerala coast. So Kovalam coast, lying immediately to the north of the proposed port, might experience erosion. Further, oil spills from the ships visiting the port would reach the sea off the nearby Kovalam coast, spoiling the place for sunbathing and swimming [98].

96 National Assessment of Shoreline Change – Kerala. www.ncscm.org accessed 20 Aug. 2012.

97 Radhakrishnan, S. A. Artificial Reef promises to boost tourism potential. The Hindu, Kerala Edition, 10 August 2010. Venugopal, P. Tourist industry in jitters over Vizhinjam. The Hindu. 13 August 2012.

The BMTPC's vulnerability assessment of Kerala puts it at moderate risk from earthquakes (Zone III) and wind & cyclones. Sections of Alappuzha and Kollam districts were affected by the waves diffracting around the Indian peninsula during the 2004 Indian Ocean tsunami. The receding waves attracted women to the shore to pick the exposed shellfish, but they were caught in the wave that subsequently returned. The waves also damaged a number of houses near the shore.

Coastal structures: Coastal structures are mainly seawalls (RMS, RCC), piers, jetties, groynes and breakwaters. A summary of the area occupied by these structures in the littoral zone as mapped in this project is given below. According to the CPDAC (Table 8.7), 347 km of the Kerala coast has been protected. In this study, 216 km of seawalls were measured.

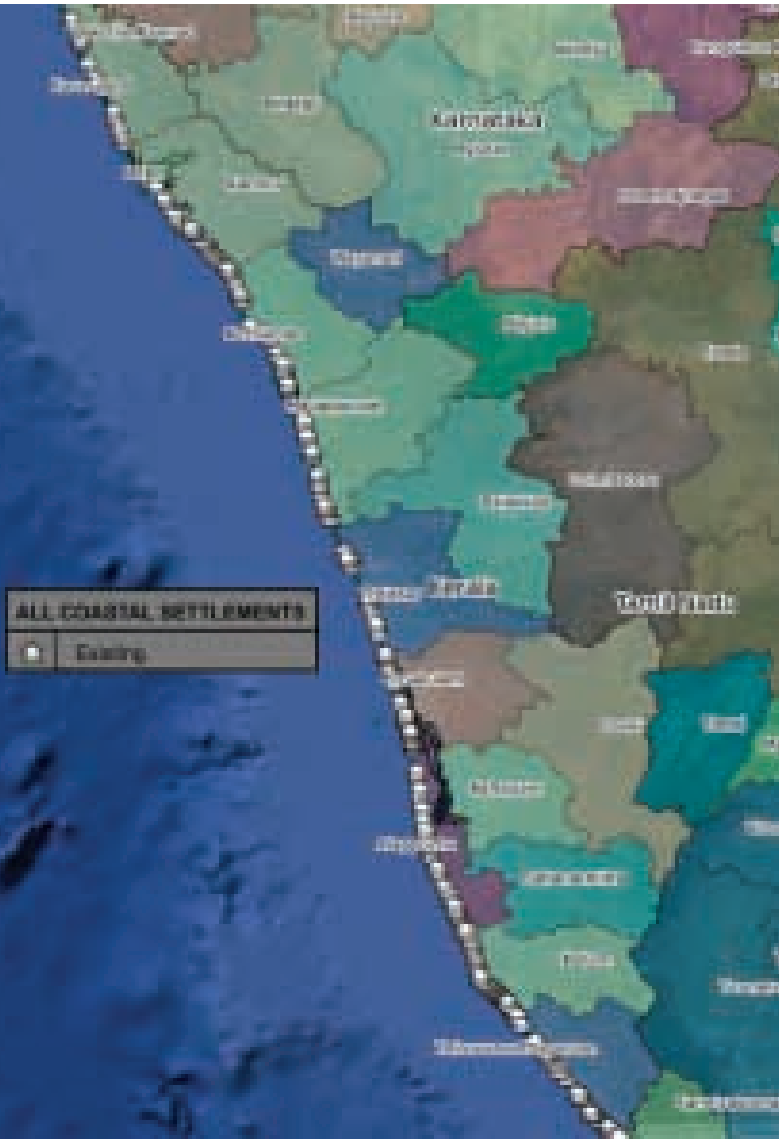


Figure 9.6.2: Settlements

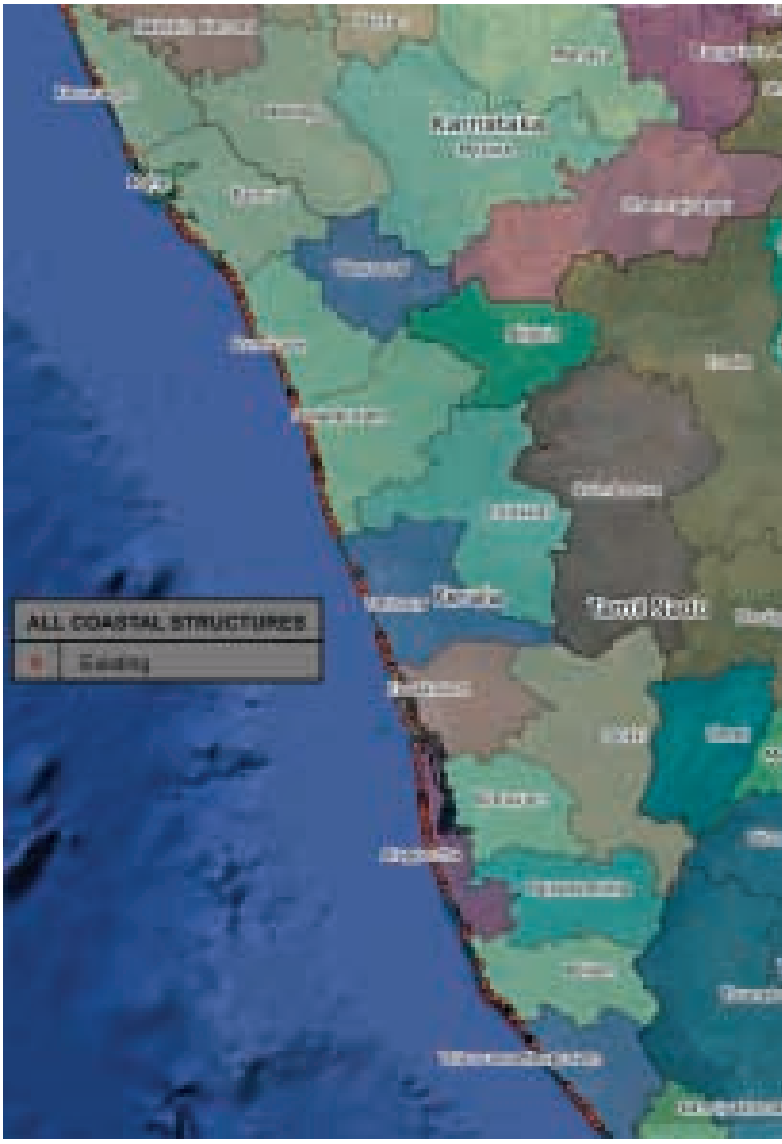


Figure 9.6.3: Structures

Table 9.6.7: Structures surveyed in this study

Structures of Kerala									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Alappuzha	2	-	-	-	-	1	-	-	3
Ernakulam	2	-	-	-	-	-	-	-	2
Kannur	2	-	-	-	-	-	-	-	2
Kasaragod	-	-	-	-	-	-	1	-	1
Kollam	8	-	-	-	-	-	-	-	8
Kozhikode	6	-	-	-	-	-	2	-	8
Malappuram	2	-	-	-	-	1	10	-	13
Trivandrum	-	-	-	-	-	1	-	-	1
Thrissur	2	-	-	-	-	-	-	-	2
Total Nos.	**24**	-	-	-	-	**3**	**13**	-	**40**
Total Length of Structures (km)	**19.6**	-	-	-	-	**0.7**	**0.5**	-	**20.8**

Table 9.6.8: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Kerala						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Alappuzha	24	35.1	44.3	40.8	2	0.3
Ernakulam	3	11.1	23.1	26.5	6	0.3
Kannur	7	2.2	2.6	4.1	3	0.8
Kasaragod	10	4.4	6.0	4.5	1	0.3
Kollam	24	66.7	131.9	208.5	42	2.1
Kozhikode	32	23.9	35.1	41.2	5	0.7
Malappuram	33	20.1	32.9	35.9	4	0.2
Thrissur	23	41.4	70.6	67.9	-	-
Trivandrum	15	11.0	15.6	13.9	7	0.9
Grand Total	**171**	**215.9**	**36.4**	**38.3**	**70**	**6.0**

A major problem is sand mining of riverbeds as well as mining of beach sand for minerals. This is said to be a major cause for erosion along the coast, where huge sections of the beach are pockmarked with pits. This is also said to be the cause of coastal flooding and unprecedented erosion along the shore, resulting in houses along the coast being inundated or even washed away.

Ports and harbours: Kerala has 1 major, 3 intermediate and 14 non-major ports; most of the non-major ports are seasonal in nature with insufficient infrastructure to handle even medium and small sized vessels throughout the year. According to Kerala's Port Policy, *inter alia*, port-based and marine industries are to be promoted while protecting the environment and coastal zones. The government would initially focus on 7 ports for development, namely Vizhinjam, Thankasserry, Alappuzha, Munambam, Ponnani, Beypore and Azhikkal[99]. Kochi is the all-weather major port located in the central part of the Kerala coast on Willingdon Island. The port's International Container Transhipment Terminal (ICTT), locally known as the Vallarpadam Terminal, is the only trans-shipment port in India. The first phase was commissioned in 2011. The Dubai Ports World has been granted a 38-year concession for the exclusive operation and management of the site[100].

The space occupied by ports and harbours in Kerala in the littoral zone as measured in this study is given in the table.

Table 9.6.9: Ports surveyed in this study

Ports & Harbours of Kerala							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Alappuzha	-	-	-	-	-	-	-
Ernakulam	1	0.6	0.3	1.2	1.4	1.4	1.6
Kannur	3	1.2	0.1	1.4	0.3	2.2	0.4
Kasaragod	1	0.1	-	0.1	-	0.1	-
Kollam	2	1.6	0.1	3.2	0.5	5.0	0.7
Kozhikode	3	1.0	0.1	1.5	0.4	1.8	0.5
Malappuram	1	0.4	0.0	0.7	0.1	0.7	0.1
Thrissur	1	0.3	0.1	0.6	0.4	0.6	0.4
Trivandrum	2	1.3	0.1	1.8	0.4	1.6	0.4
Grand Total	**14**	**6.5**	**1.0**	**1.1**	**0.3**	**1.2**	**0.4**

Table 9.6.10: Proposed ports

Proposed ports		
No. of ports State	**District**	**Total**
Kerala		
	Alappuzha	1
	Ernakulam	1
	Kannur	1
	Kozhikode	1
	Trivandrum	1
Total		**5**

99 Government of Kerala, Department of Port. http://www.kerala.gov.in/index.php?option=com_content&view=article&catid=119:port-department&id=1873:port-department-port&Itemid=2257 accessed 12 Sep. 2012.

100 International Container Transshipment Terminal, Kochi. http://en.wikipedia.org/wiki/International_Container_Transshipment_Terminal,_Kochi

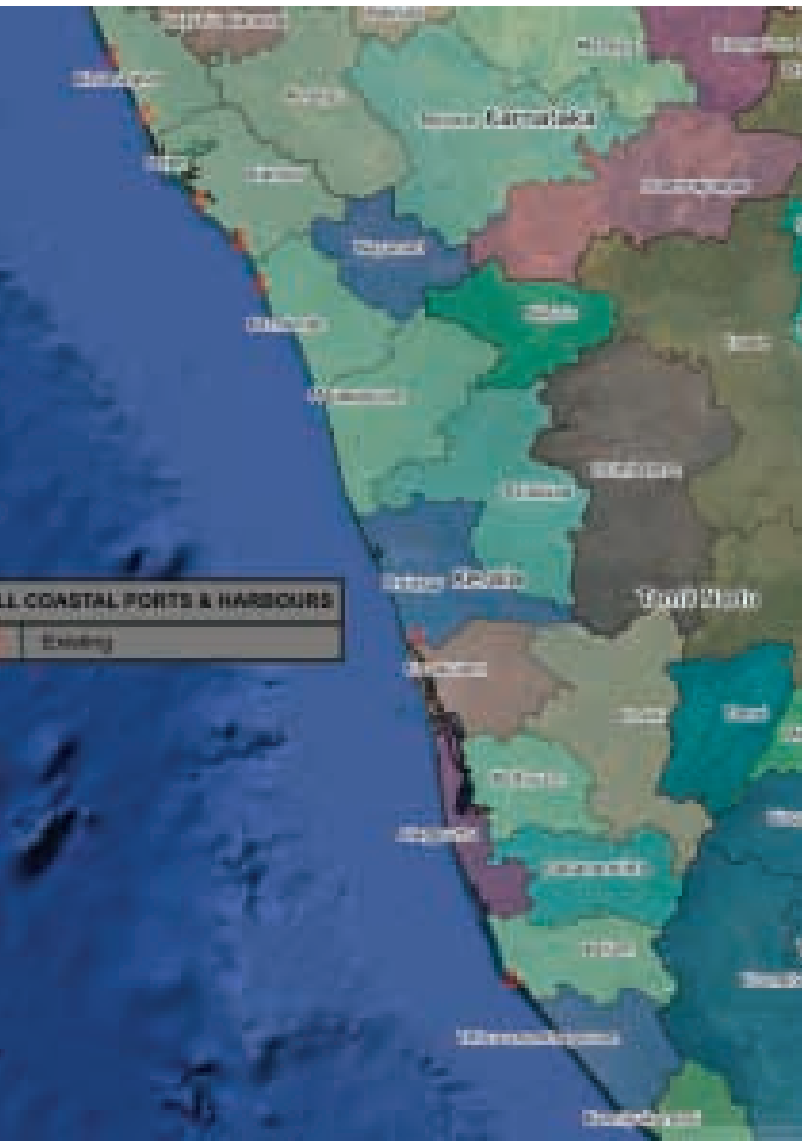


Figure 9.6.4: Ports

Figure 9.6.5: Power Plants

Thermal power plants: Upcoming: KSIDC is planning to set up a 1,200 MW gas-based combined cycle power plant at Cheemeni village in Kasargod district likely to use water from the sea to meet its water requirements. The government has allotted 2,000 acres of land and is in process of selecting a developer[101]. Petronet LNG is planning to set up a 750 MW gas-based power project near its LNG terminal in Kochi, with an investment of Rs. 30,000 million[102].

Table 9.6.11: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	District	Type	Project Name
1	Alappuzha	Gas and liquid fuel	Rajiv Gandhi CCPP
2	Kochi	Gas and liquid fuel	Kochi Combined Cycle Power Station

Table 9.6.12 Proposed thermal power plants

Proposed power plants - coastal					
1	Fuel	District	Village	Company	Ownership
2	Coal	Kasaragod	Cheemeni	Kerala State Industrial Development Corporation Ltd.	state

101 Kerala Power Co. plans 1,200 MW gas based power project at Kasargod. http://thermalpower.industry-focus.net/kerala-thermal-power-projects.html accessed 1 September 2012.

102 Petronet LNG plans 750 MW gas power project in Kochi. http://thermalpower.industry-focus.net/kerala-thermal-power-projects/503-petronet-lng-plans-750-mw-gas-power-project-in-kochi.html accessed 1 September 2012.

In addition to the proposed power plant in Kasaragod district, only incorrect coordinates are available for one proposed plant in Alappuzha district; for another, coordinates are the same as another proposed project in Kasaragod.

Special economic zones: According to the Ministry of Commerce & Industry, Govt. of India, there are **7** operational SEZs in Kerala. After the SEZ Rules 2006 came into force, formal approvals were granted to **28** more SEZs in the State.

Challenges/issues in the coastal zone: Kerala has a number of problems along the shoreline – from beach sand mining, which has eroded large sections of the coast, to tourism pressures and demands for developments such as ports. Beach sand mining for rare earths is a major industry. Kerala's traditional fishing community is active, and has protested extensively about the various issues that affect both the coast and coastal livelihood, especially of the fishing community.

9.7. Tamil Nadu

Introduction: Tamil Nadu has part of its coastline along the Arabian Sea, but most of it along the Gulf of Mannar, Palk Bay and the Bay of Bengal. It is the eleventh largest state in India by area, the seventh most populous state and is described as the most urbanized. There are 13 coastal districts. The length of the coastline surveyed in this study is about 977 km and is detailed in the table below:

Table 9.7.1: Length of coastline

Length of Coastline - Tamil Nadu		
Districts	Length (Surveyed)	Length (Natmo)
Viluppuram	26.1	34.0
Tirunelveli	47.3	59.0
Thoothukudi	130.0	81.0
Thiruvallur	40.7	48.0
Thanjavur	57.2	51.0
Ramanathapuram	272.0	248.0
Pudukkottai	39.1	43.0
Nagapattinam	136.1	129.0
Kanyakumari	66.2	62.0
Kanchipuram	100.0	93.0
Cuddalore	52.5	45.0
Chennai	10.3	18.0
Grand Total	977.5	911.0

According to studies by the NHO (Table 8.7), the coastline of Tamil Nadu is about 907 km long. About 57% of it is sandy beach, 5% rocky coast and 38% mudflats. In 2004, it was reported that 36 km of the coast was affected by erosion, whereas by October 2010, just 6 years later, the figure had shot up to 152 km, or over a sixth of the coast. 76 km of the coast have been protected so far. The National Assessment of Shoreline Change[103] for Tamil Nadu says that 31 km or 3.1% of the coast is artificially protected. About 13 km or 1.3% fall in the high erosion zone, while 31 km or 3.1% fall in the high accretion zone. There are 272 groynes and three breakwaters, according to their report.

According to the BMTPC's vulnerability assessment of Tamil Nadu, most of coastal Tamil Nadu falls under Zone II or Low Damage Risk zone with respect to earthquakes. The southernmost district of Kanyakumari as well as Chennai-Kancheepuram-Tiruvallur, which are part of north TN, fall in the Zone III or Moderate Damage Risk zone. On the other hand, three-quarters of TN's coast (including Rameswaram) falls under the Very High Damage Risk zone with respect to cyclone and wind. Cyclones are common in the Bay of Bengal and frequently cross the TN coast, causing considerable damage. The most recent was Cyclone Thane in 2011, which made landfall between Cuddalore and Puducherry, causing extensive damage.

When the 2004 tsunami ravaged Tamil Nadu's coast, it was the fishing community that suffered the greatest losses in terms of lives, houses, craft and gear. The Tamil Nadu government along with NGOs facilitated the

103 National Assessment of Shoreline Change. www.ncscm.org

rebuilding of some 30,000 houses of the affected populace, most close to the shoreline. The move resulted in mass replacement of a number of traditional structures (built of thatch, mud, etc) with RCC structures. As part of the recovery programme, the Nagapattinam harbour was rebuilt, and other smaller projects including stabilizing estuary mouths were taken up under various funding schemes.

Ecology and biodiversity: Tamil Nadu has many stretches of dense mangroves located along the numerous creeks and estuaries that crisscross the coast, especially in the delta of the River Cauvery. Well-known mangrove stands are located at Pichavaram in Cuddalore district and Muthupet in Nagapattinam district. A large coastal lagoon, Pulicat, is shared with the neighbouring state of Andhra Pradesh. The mud-flats of Vedaranyam and Point Calimere are known for large numbers of migratory birds.

Table 9.7.2: List of wetlands[104]

Wetlands of Tamil Nadu							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Chennai	2	2	-	5	-	1	-
Cuddalore	13	6	-	8	-	3	9
Kancheepuram	2	5	-	7	-	1	4
Kaniyakumari	-	-	1	5	-	-	6
Nagapattinam	24	7	1	9	-	2	20
Pudukkottai	5	-	2	-	-	1	7
Ramanathapuram	10	-	4	21	32	16	25
Thanjavur	9	-	3		-	2	7
Tirunelveli	-	-	-	5	-	-	-
Thiruvallur	6	-	63	4	-	-	-
Tiruvarur	4	-	2	-	-	-	5
Thoothukkudi	9	-	1	14	4	17	9
Viluppuram	1	-	-	2	-	-	1
Grand Total	**85**	**20**	**77**	**80**	**36**	**43**	**93**

Table 9.7.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of Tamil Nadu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Chennai	-	-	-	-	-	-	-
Cuddalore	1	4.7	2.4	9.0	9.0	10.4	10.4
Kanchipuram	-	-	-	-	-	-	-
Kanyakumari	-	-	-	-	-	-	-
Nagapattinam	2	21.3	10.7	15.7	15.7	16.5	16.5
Pudukkottai	-	-	-	-	-	-	-
Ramanathapuram	1	114.6	57.5	42.1	42.3	46.2	46.4
Thanjavur	-	-	-	-	-	-	-
Thiruvallur	-	-	-	-	-	-	-
Thoothukudi (Tuticorin)	-	-	-	-	-	-	-
Tirunelveli	-	-	-	-	-	-	-
Viluppuram	-	-	-	-	-	-	-
Grand Total	**4**	**140.6**	**70.5**	**14.4**	**14.4**	**15.4**	**15.5**

104 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

The Gulf of Mannar Biosphere reserve is located in Tamil Nadu. 'This is the first Marine Biosphere Reserve in south and southeast Asia. The IUCN Commission on National Parks and WWF identified the Reserve as being an area of "Particular concern" given its diversity and special multiple-use management status. The Gulf of Mannar and its 3,600 species of flora and fauna is one of the biologically richest coastal regions in all of mainland India. It is equally rich in sea-algae, sea grasses, coral reef pearl banks, fin & shellfish resources, mangroves, and endemic and endangered species. It is an important habitat for the highly endangered sea mammal, the Dugong, commonly called the sea cow'[105] as the Gulf contains large seagrass beds, the habitat of this animal, which are also the feeding grounds for five species of turtles. The area is facing threats from overfishing, destructive fishing and over-exploitation of resources e.g. coral mining and seaweed collection, as well as from pollution and extensive industrial development along the coast[106].

PHOTO : V KARTHIK

Figure 9.7.1: Painted Storks near Marakkanam

Table 9.7.4: Water bodies surveyed in this study

Water Bodies of Tamil Nadu								
Tamil Nadu	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Chennai	-	2	1.5	0.4	14.8	8.4	8.4	4.8
Cuddalore	5	3	9.3	2.6	17.7	9.9	20.6	11.5
Nagapattinam	15	11	9.7	2.2	7.1	3.2	7.5	3.4
Pudukkottai	2	10	4.4	1.2	11.2	6.3	10.2	5.7
Ramanathapuram	11	19	12.6	2.4	4.6	1.8	5.1	2.0
Thanjavur	2	10	15.3	22.4	26.7	78.2	30.0	87.7
Thiruvallur	3	1	3.8	1.5	9.3	7.1	7.9	6.0
Thoothukudi	10	11	11.6	2.6	8.9	4.0	14.3	6.5
Kanchipuram	2	6	11.3	3.0	11.3	6.1	12.1	6.5
Kanyakumari	4	1	2.9	0.4	4.3	1.2	4.6	1.3
Tirunelveli	9	3	2.8	0.4	5.9	1.7	4.8	1.4
Viluppuram	1	-	0.1	-	0.2	-	0.2	-
Grand Total	**64**	**77**	**85.1**	**39.1**	**8.7**	**8.0**	**9.3**	**8.6**

105 Gulf of Mannar Biosphere Reserve. http://www.ramnad.tn.nic.in/biosphere.htm accessed 1 September 2012.
106 Ibid.

Coastal settlements: The space and length of the coast occupied by coastal settlements in the 500 m zone was mapped in this project and is summarized below in a table.

Table 9.7.5: Settlements surveyed in this study

Settlements of Tamil Nadu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Chennai	7	13.4	5.7	130.4	111.1	74.6	63.6
Cuddalore	21	9.5	2.9	18.1	10.9	21.1	12.7
Nagapattinam	39	19.6	8.0	14.4	11.8	15.2	12.5
Ramanathapuram	50	31.8	10.1	11.7	7.4	12.8	8.2
Thanjavur	9	4.7	1.6	8.2	5.5	9.2	6.2
Thoothukudi	19	13.0	4.8	10.0	7.5	16.0	12.0
Thiruvallur	14	11.8	3.8	28.9	18.4	24.5	15.6
Pudukkottai	18	8.9	2.2	22.9	11.2	20.8	10.1
Kanchipuram	38	24.8	9.5	24.8	19.1	26.7	20.5
Kanyakumari	57	39.5	6.9	59.7	20.8	63.7	22.2
Tirunelveli	16	9.0	2.7	19.1	11.6	15.3	9.3
Viluppuram	21	12.1	4.1	46.2	31.5	35.5	24.2
Grand Total	**309**	**198.1**	**62.3**	**20.3**	**12.8**	**21.8**	**13.7**

In an earlier study[107] after the 2004 tsunami, it was found that of the 51 villages sampled in Tamil Nadu, 42% (22) of them are within 50 m from the shore, 71% (36) are within 200 m, and 92% (47) are within 500m from the shore. This supports the current observation of high occupation of the 500m strip from the shoreline by settlements in Tamil Nadu.

The table below gives information from the latest (2010) census carried out by CMFRI.

Table 9.7.6: District-wise population of marine fishing communities (CMFRI census 2010)

District	Number of hamlets	Total families	Traditional families	BPL families	Total population
Thiruvallur	26	7,544	7,543	7,240	28,109
Chennai	44	15,176	13,653	14,445	67,464
Kanchipuram	42	8,469	8,463	8,436	29,974
Villupuram	19	4,720	4,710	4,716	18,124
Cuddalore	42	12,714	12,548	10,588	48,518
Nagapattinam	57	21,122	20,854	13,927	84,369
Tiruvarur	13	2,580	2,577	2,080	9,995
Thanjavur	31	6,530	6,528	6,483	29,849
Pudukottai	33	6,398	6,015	2,689	29,663
Ramanathapuram	178	41,048	37,680	33,429	193,413
Tuticorin	32	19,998	18,828	13,212	82,560
Tirunelveli	9	6,132	6,125	2,399	24,639
Kanyakumari	47	40,266	39,941	7,601	156,595
Tamil Nadu	**573**	**192,697**	**185,465**	**127,245**	**802,912**

107 Rodriguez, S., G. Balasubramanian, M. P. Shiny, M. Duraiswamy and P. Jaiprakash. 2008. Beyond the Tsunami: Community Perceptions of Resources, Policy and Development, Post-Tsunami Interventions and Community Institutions in Tamil Nadu, India. UNDP/UNTRS, Chennai and ATREE, Bangalore, India. p 78.

Fishing: The total marine fish production in Tamil Nadu during the year 2010 was 555,000 tonnes. The mechanised sector contributed 65% to the total landings, motorised sector 34%, and the non-mechanised sector only 1%. Trawl landings formed 59% of the total landings. Analysis of landings data for the period from 2006 to 2010 showed that the annual landings in Tamil Nadu increased from 362,000 tonnes in 2006 to 555,000 tonnes in 2010. Oil sardine, Silverbellies and other sardines remained the top three contributors during the period.

Commercial Areas: The commercial spaces within the 500m zone from the shoreline were also mapped in the study and are presented in the table below.

Table 9.7.7: Commercial areas surveyed in this study

Commercial Areas of Tamil Nadu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Chennai	18	9.7	2.9	94.5	55.3	54.1	31.7
Cuddalore	16	6.7	1.3	12.8	4.8	14.9	5.6
Nagapattinam	39	20.9	9.5	15.4	13.9	16.2	14.7
Pudukkottai	12	9.2	2.5	23.5	12.8	21.4	11.7
Ramanathapuram	65	34.2	6.1	12.6	4.5	13.8	4.9
Thanjavur	8	15.5	7.3	27.0	25.6	30.3	28.7
Thiruvallur	36	11.4	4.8	28.1	23.5	23.8	20.0
Thoothukudi	27	45.6	61.1	35.0	94.0	56.2	150.8
Kanchipuram	70	27.6	6.2	27.6	12.4	29.7	13.3
Kanyakumari	25	21.6	1.6	32.7	4.7	34.9	5.1
Viluppuram	31	12.8	1.8	48.9	13.5	37.6	10.4
Tirunelveli	11	5.7	0.4	12.1	1.9	9.7	1.5
Grand Total	**358**	**220.9**	**105.3**	**22.6**	**21.6**	**24.3**	**23.1**

Salt: Tamil Nadu is the second largest producer of sea salt after Gujarat, though the share is just 12% of the total. Salt is produced in Tuticorin, Vedaranyam (Nagapattinam district) and Kovalam (Kancheepuram district). In 2010, the area allocated for salt production was 806,000 acres. However, salt pans near port areas as well as industries are now being converted into warehouses, industries and even residential plots, as in Tuticorin where a major port is located[108].

Coastal structures: Coastal structures are mainly breakwaters, seawalls, groynes (RMS, RCC), piers and jetties. A summary of the area occupied by these structures in the littoral zone as mapped in this project is given below.

108 Jeyasingh Satyaraj, J. Thoothukudi realtors gorge salt pans. http://ibnlive.in.com/news/thoothukudi-realtors-gorge-salt-pans/247074-60-118.html accessed 1 September 2012.

Table 9.7.8: Structures surveyed in this study

Structures of Tamil Nadu									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Chennai	8	-	-	-	-	1	-	-	9
Cuddalore	3	-	-	1	-	2	-	-	6
Kanchipuram	-	-	-	-	-	2	-	-	2
Kanyakumari	5	-	-	-	-	1	-	-	6
Nagapattinam	2	-	-	-	-	2	-	-	4
Ramanathapuram	1	1	-	8	-	4	-	-	14
Thanjavur	-	-	-	3	-		-	-	3
Tirunelveli	7	-	-	-	-		-	-	7
Thoothukudi	7	-	-	1	-	-	-	-	8
Villuppuram	-	-	-	-	-	-	-	-	-
Total Nos.	**33**	**1**	-	**13**	-	**12**	-	**-**	**59**
Total length of structures (km)	**27.6**	**2.2**	-	**2.2**	-	**2.6**	-	**-**	**34.6**

Figure 9.7.2: Settlements

Figure 9.7.3: Structures

Table 9.7.9: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Tamil Nadu						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Chennai	12	9.3	90.3	52.0	12	2.4
Cuddalore	1	0.8	1.5	1.8	-	-
Kanchipuram	2	1.8	1.8	1.9	3	0.3
Kanyakumari	4	0.8	1.2	1.3	20	7.0
Nagapattinam	3	1.4	1.0	1.1	1	0.1
Pudukkottai	-	-	-	-	-	-
Ramanathapuram	2	9.6	3.5	3.9	1	0.1
Thanjavur	-	-	-	-	-	-
Thiruvallur	-	-	-	-	-	-
Thoothukudi	2	2.0	1.5	2.5	2	0.1
Tirunelveli	3	1.6	3.4	2.7	4	0.6
Viluppuram	4	1.4	5.4	4.1	6	0.4
Grand Total	**33**	**28.7**	**2.9**	**3.2**	**49**	**11.0**

Ports and harbours

Tamil Nadu has two major ports, at Chennai and Tuticorin, as well as the corporate port of Ennore. In addition there are 15 minor ports at Cuddalore, Nagapattinam, Pamban, Rameswaram, Valinokkam, Kanyakumari, Colachel, Kattupalli, Ennore, Thiruchopuram, PY-03 Oil Field, Thirukkadaiyur, Punnakkayal, Koodankulam and Manappad.

Table 9.7.10: Ports surveyed in this study

Ports & Harbours of Tamil Nadu							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Chennai	4	6.5	5.9	63.0	100.0	36.0	66.0
Cuddalore	2	0.4	0.3	1.0	1.0	1.0	1.3
Kanchipuram	-	-	-	-	-	-	-
Kanyakumari	2	0.2	0.1	0.3	0.3	0.3	0.3
Nagapattinam	2	1.4	0.4	1.0	0.6	1.1	0.6
Pudukkottai	-	-	-	-	-	-	-
Ramanathapuram	2	0.4	0.2	0.1	-	0.2	0.2
Thanjavur	-	-	-	-	-	-	-
Thiruvallur	2	4.8	7.0	11.8	34.4	10.0	29.2
Thoothukudi	4	5.6	13.6	4.3	20.9	6.9	33.6
Tirunelveli	1	0.1	0.1	0.2	0.4	0.2	0.3
Viluppuram	-	-	-	-	-	-	-
Grand Total	**19.0**	**19.4**	**27.6**	**2.0**	**5.6**	**2.1**	**6.1**

The non-major ports in Tamil Nadu are administered and controlled by the Tamil Nadu Port Department. The objectives of this department are given as[109]:

- To facilitate establishment of port based thermal power plants by providing exclusive port facilities
- To provide port facilities to promote export-oriented industries and port-based industries along the coastal area
- To decongest highways and railways by providing facilities for coastal traffic along the East Coast.
- To promote tourism, cruises and coastal trade.

The area occupied by ports and harbours in Tamil Nadu in the littoral zone as measured in this study is given in the table.

Table 9.7.11: Proposed ports

Proposed ports		
No. of ports State	**District**	**Total**
Tamil Nadu	**Chennai**	1
	Cuddalore	3
	Kanchipuram	3
	Nagapattinam	5
	Thiruvallur	1
	Thoothukudi	3
	Villuppuram	1
Total		**17**

Thermal power plants: Tamil Nadu has four major coal-based thermal power plants. They are Ennore thermal power station, Tuticorin thermal power station, Mettur thermal power station, and North Chennai thermal power station. Mostly the coal comes from the mines Talcher and Ib Valley of MCL and Raniganj and Mugma of ECL[110]. Coastal TN also has gas-based and atomic power plants as listed in the table below.

Table 9.7.12: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	**District**	**Type**	**Project Name**
1	Chennai	Gas and liquid fuel	Basin Bridge Gas Turbine Power Station
2	Chennai	Thermal-coal	Ennore Thermal Power Station
3	Kancheepuram	Atomic	Madras Atomic Power Station
4	Nagapattinam	Gas and liquid fuel	PPN Combined Cycle Power Plant
5	Thiruvallur	Thermal-coal	North Chennai Thermal Power Station
6	Tirunelveli	Atomic	Kudankulam Nuclear Power Plant
7	Tuticorin	Thermal-coal	Tuticorin Thermal Power Station

A number of other thermal power plants are also coming up, as given in the table below.

109 Tamil Nadu Maritime Board http://www.tnmaritime.com/index.php accessed 1 September 2012.

110 List of thermal power plants in Tamil Nadu. http://www.globalshiksha.com/list+of+thermal+power+plants+in+tamil+nadu/search/ accessed 1 September 2012.

Table 9.7.13: Proposed thermal power plants

Proposed power plants - coastal					
	Fuel	**District**	**Village**	**Company**	**Ownership**
1	Coal	Cuddalore	Thiyagavalli and Kudikadu	BGR - Cuddalore Power Co. Ltd.	Private
2	Coal	Nagapattinam	Nagapattinam	Nagai Power Pvt. Ltd.	Private
3	Coal	Nagapattinam	Neidavasal	Empee Power and Infrastructure Private Ltd	Private
4	Coal	Nagapattinam	Kilvelur Taluk	Nagi Power Pvt. Ltd.	Private
5	Coal	Nagapattinam	Akurumukutu	Patel Power Ltd.	Private
6	Coal	Nagapattinam	Pillaiperumalnallur	PPN Power Generation Co.(P) Limited	Private
7	Coal	Nagapattinam	Erukkattanchery, Kazhizppanallur and Manichkapangu	Chettinad Power Corportion	Private
8	N.A.	Nagapattinam	Marudampallam, Keelperumpallam	Laksha Infra Projects Private Ltd.	Private
9	Coal	Perambalur	Udayapalayam	NLC	Central
10	Coal	Tiruvallur	Ennore	NTPC-TN Energy Co. Ltd.	State+ Central
11	Coal	Tiruvallur	Kattupalli & kalanji	North Chennai Power Co. Ltd.	State
12	Coal	Tuticorin	Melamaruthur	Coastal Energen Pvt. Ltd.	Private
13	Coal	Tuticorin	Tuticorin	Neyveli Lignite Corporation Ltd.	Central
14	Coal	Tuticorin	Adiyakurichi	NC Energy Ltd.	Private

PHOTO: SUDARSHAN RODRIGUEZ

Figure 9.7.4 Tuticorin Thermal Power Plant

In addition to the above listed 14 proposed plants, the coordinates of 5 plants have been given incorrectly; for 6 proposed plants no coordinates are available; for 5, coordinates are the same as given for other projects; and 12 are to be located more than 10 km from the coast.

Almost all of the plants are in coastal districts. They are in varying stages of environmental clearances.

Figure 9.7.5: Ports

Figure 9.7.6: Power Plants

Challenges/issues in the coastal zone: Concern about the deteriorating state of the coast has been on the high since the 2004 Indian Ocean tsunami that affected all 13 coastal districts to varying degrees. That ports have an impact on the coastline has long been known, thanks to the development of Chennai's Marina beach. The best studied among ports is Chennai port's impact on the shoreline. The vast Marina beach of Chennai was formed because of the breakwaters of the Chennai port blocking the littoral drift. This resulted in the formation of the Royapuram Bay due to erosion in the north. This has been used to extend the Chennai port and also to develop the fisheries harbour with minimal capital dredging. However, severe erosion has affected the beaches north of Royapuram, resulting in the placement of a groyne field to try to arrest the problem. In recent times, the problem appears to have worsened, with houses along the shore falling into the sea and more frequent reports of flooding of coastal hamlets in that area. In May 2012, reports of sudden erosion near the fishing hamlet of Nettukuppam resulted in the loss of 30 metres of beach overnight. The sudden erosion of the coast in Nettukuppam is not an isolated incident. Fishermen from Kadalore Periyakuppam in Kancheepuram district also reported that 30 metres of beach vanished overnight, a day before the full moon, about the same time as the Nettukuppam erosion. Houses built after the tsunami were found with their foundations exposed due to the intense wave action and erosion of the shore barely a couple of weeks later[111]. According to WRD sources, so far some 350 hectares of land have been lost along the Chennai coast in the past four decades[112]. In addition to

111 Ramakrishnan, D.H and K. Lakshmi. For want of a wall, the house was lost. The Hindu, Chennai, 30 May, 2012.

112 Ramakrishnan, D.H and K. Lakshmi. Sea wall to rein in coastline. The Hindu, Chennai, 13 May, 2012.

all this there is increasing salinity of groundwater, which forces residents to buy packaged water that they can ill afford.

The Marina beach has resulted in siltation of the mouth of the Cooum. An attempt to resolve the problem by constructing a groyne/training jetty resulted in the loss of some portions of the Marina. Ennore port is located north of Chennai port between Ennore and Pulicat. Right from the construction stage the port caused changes in the shoreline, with accretion and siltation on the southern side in front of the Ennore creek inlet, and severe erosion of the sand barrier between Pulicat Lake and the sea on the northern side. ICMAM has prepared a shoreline management plan for Ennore[113].

Stiff opposition has been raised to a number of upcoming power plants in coastal areas, especially in Nagapattinam. For example, in 2009 the public hearing of the 1,000 MW coal-based thermal power plant at Marudampallam village had to be postponed twice. The company had acquired 1,013 acres of land in three villages. The plant would have units for coal import, storage and handling, seawater intake, desalination unit, effluent discharge into the sea, and ash management systems[114]. It was pointed out by others that agricultural land had been acquired by middlemen under the garb of using it for agriculture before selling it to the power plant. The thermal power plant, which would release 200,000 gallons of hot water into the sea daily, along with fly ash, would cause environmental pollution and jeopardize the livelihood of fisherfolk and farmers, as well as block access to the seashore[115]. More recently, a public hearing was held for a 1,300 MW thermal power plant by Sindya Power Generating Company Private Limited at Perunthottam village in Sirkazhi Taluk, where a 660x2 MW thermal power plant and a captive jetty at an estimated cost of Rs. 7,000 crore are to come up. Problems highlighted at the public hearing included the non-employment of locals in earlier projects, despite promises made, and loss of livelihoods to the thriving fishing community in the area due to the development of the captive jetty and contamination by the thermal power plant. In addition, the report about the meeting also said that the Forest Department had contested the EIA, which held that there were no endangered or threatened species in the project area. The EIA had said that the Olive Ridley turtle nesting was only a sporadic phenomenon and that they would establish adequate hatcheries for their protection. Dismissing the company's submission, the department has stated that Olive Ridleys do not have a particular place of habitation and they were by nature migratory along their chosen coastal nesting sites. Further, dismissing the company's case for establishing hatcheries as part of coastal habitat management, the department said that Olive Ridleys are not reared in captivity and there was no point in creating hatcheries after destruction of their nesting sites. The proposed site for laying of pipelines and a conveyor system from the captive jetty to the plant passes through turtle nesting and hatching areas[116].

9.8. Puducherry Union Territory

Introduction: Puducherry is a Union Territory (U.T.) of India formed out of four enclaves of former French India consisting of four districts, Puducherry, Karaikal, Mahe and Yanam. All four districts are coastal districts, However, because Yanam is located along the banks of the river Gautami of the Godavari delta, further inland and away from the littoral zone surveyed in this study it finds itself excluded from all of the survey data.

The enclaves of Puducherry and Karaikal are carved out of the Tamil Nadu state. Yanam and Mahé have been carved out of the states of Andhra Pradesh and Kerala respectively. The union territory has a total area of 492 km² in which Puducherry is the largest district with an area of 293 km², Karaikal is the second largest district with an area of 160 km², Yanam with an area of 30 km² and Mahé the smallest district with an area of only 9 km². The Pondicherry town is the capital of the Puducherry Union Territory and is predominantly an urban agglomeration.

The district-wise length of the coastline of the Puducherry U.T. is given in the table 9.8.1 below. There appear to be significant differences between the lengths of coastline measured during our survey and those recorded by NATMO. While a certain amount of variation is to be expected, what is unusual is the variance between the differences of the coastline lengths measured; for instance in the case of the Puducherry district the variance

113 ICMAM, 2006. Shoreline management plan for Ennore coast, Tamil Nadu. http://www.icmam.gov.in/slmennore.pdf

114 Thermal Plant hearing held, at last. The New Indian Express, Tiruchy, 30 October, 2009.

115 Residents of five villages oppose proposed thermal power plants. The Hindu, Tiruchirapalli, 29 October, 2009.

116 Srividya, P.V. Sparks fly at public hearing on power plant in Sirkazhi taluk. The Hindu. Nagapattinam, 18 February 2012. http://www.thehindu.com/news/states/tamil-nadu/article2907511.ece

between the differences of the coastline lengths measures is of 35% whereas in the case of the Karaikal district the variance is of 200%. A large variance of coastline lengths measured during different surveys using different scales could be expected on a coastline that is non-linear and irregular but such a variance is unusual given the linear nature of all districts of the Puducherry coast.

Table 9.8.1: Length of coastline

Length of Coastline - Puducherry		
Districts	Length (Surveyed)	Length (Natmo)
Yanam		1.5
Pondicherry	24.2	18.0
Mahe	3.3	6.0
Karaikal	18.1	6.0
Grand Total	**45.7**	**31.5**

Pondicherry is described as being highly vulnerable to wind and cyclones by the BMTPC vulnerability atlas, and at medium to low risk from earthquakes. Most recently, on 30t^{h} December Cyclone Thane ripped across Puducherry as it made landfall just south of the town, and caused considerable damage. Karaikal, an enclave wedged within Nagapattinam district, suffered considerable damage during the 2004 Indian Ocean tsunami.

Ecology and biodiversity: Pondicherry is dominated by inland wetlands such as Ousteri and Bahour Tank (fresh water), the marshy area near lighthouse (brackish water) and extended backwaters found in Karaikal, which attract huge numbers of water birds, both migratory and resident. They mainly include duck, teal, pochards and waders which are migrants spending the winter. Mangrove vegetation is seen to some extent in the estuaries and along the sides of Ariyankuppam river (in Pondicherry region), and Gouthami river near Guirempeta (in Yanam region). Olive Ridleys and Leatherback turtles nest on some of the beaches. The threats are mainly due to the loss of beaches and destruction of mangroves due to developmental pressures. Coastal waterbodies mapped in this study are given in the table below.

Table 9.8.2: List of wetlands[117]

Wetlands of Puducherry							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Karaikal	-	1	-	1	-	-	5
Puducherry	-	5	-	6	-	1	1
Yanam	6	-	-	-	-	-	4
Grand Total	**6**	**6**	**-**	**7**	**-**	**1**	**10**

Table 9.8.3: Water bodies surveyed in this study

Water Bodies of Puducherry								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Karaikal	1	3	1.6	0.4	9.0	4.3	27.0	13.1
Mahe	1	-	0.7	0.2	-	-	11.2	7.3
Puducherry	2	-	1.5	0.6	6.2	5.2	8.3	7.0
Yanam	-	-	-	-	-	-	-	-
Grand Total	**4**	**3**	**3.8**	**1.2**	**8.9**	**5.9**	**12.0**	**7.9**

117 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Figure 9.8.1: Puducherry enclave of Puducherry Union Territory

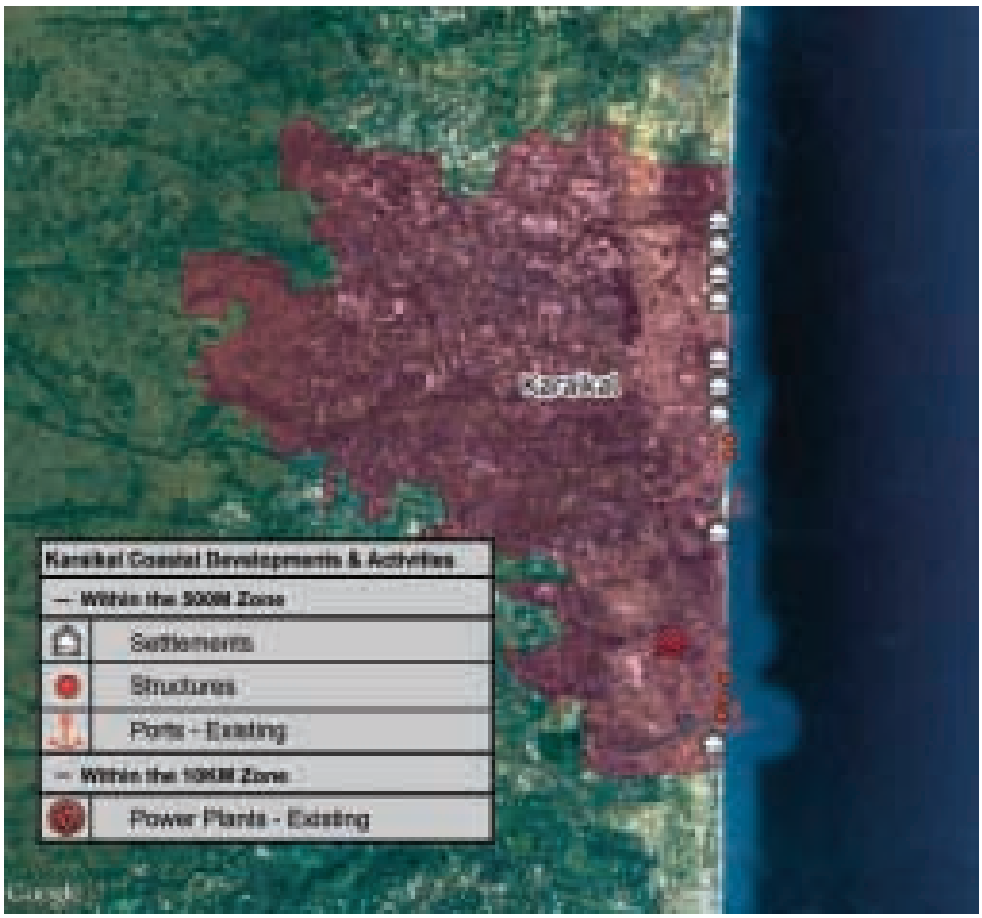


Figure 9.8.2: Karaikal enclave of Puducherry Union Territory

Figure 9.8.3: Mahé enclave of Puducherry Union Territory

Coastal settlements: The space occupied by communities in the littoral zone (up to 500 m from the shoreline) is given in the table below, based on mapping data from this study.

Table 9.8.4: Settlements surveyed in this study

Settlements of Puducherry							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Mahe	4	3.5	2.0	78.0	89.0	58.0	67.0
Karaikal	8	2.4	1.1	13.0	12.0	40.0	37.0
Pondicherry	8	6.7	0.3	28.0	27.0	37.0	37.0
Yanam	-	-	-	-	-	-	-
Grand Total	**20**	**12.6**	**3.4**	**27.0**	**15.0**	**42.0**	**23.0**

Table 9.8.5: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
Yanam	12	3,752	3,752	3,618	14,893
Puducherry	17	7,088	7,086	5,193	25,892
Karaikal	10	3,077	3,060	2,072	11,294
Mahe	1	352	350	115	2,548
Total	40	14,269	14,248	10,998	54,627

Fishing: The total landing at Puducherry was 14,525 tonnes, of which 41% was landed by trawlers. The mechanised sector contributed 44.8% to the total landings, motorised 55.1%, and the non-mechanised sector 0.1%. At Puducherry also, like in Tamil Nadu, oil sardine was dominant in the landings[118]. The fisher population of the four enclaves of Puducherry as enumerated by the CMFRI 2010 census is given in the table. As can be seen, most of the population belongs to the traditional fishing community.

Commercial Areas: The space occupied by commercial activities within 500 m of the coast has also been mapped in this study, given in the table below.

Table 9.8.6: Commercial areas surveyed in this study

Commercial Areas of Puducherry							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (NATMO) (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Karaikal	9	3.0	0.7	16.3	7.7	49.2	23.1
Yanam	-	-	-	-	-	-	-
Mahe	-	-	-	-	-	-	-
Pondicherry	16	3.0	0.6	12.6	4.6	16.9	6.2
Grand Total	**25**	**6.0**	**1.3**	**13.1**	**5.5**	**19.0**	**8.0**

118 CMFRI Annual Report 2010-11.

Shore line change: The coast of the Puducherry district experiences considerable human-induced erosion. The town was protected from the sea by a two-kilometer long masonry seawall, first erected by the French in 1735, which reaches a height of about 27 feet above sea level. After the beach at the base of the masonry seawall was lost due to human-induced erosion, the masonry seawall has been protected from the direct action of waves with a seawall which is strengthened by the Government every other year to stop erosion, whenever gaps appear or the stones sink into the sand. According to the National Assessment of Shoreline Change for Puducherry coast, overall, Puducherry has a 30.6 km coastline of which 9.5 km is undergoing erosion (as of 2010; see Table 8.7). According to our survey about 6.5 km of the Union Territory's coast has been protected so far with 14% of the coast now being artificial (having seawalls/ripraps). The Pondicherry district is the worst affected having a 5.8 km long seawall covering about 24% or a quarter of the district's coastline.

PHOTO: SVEN ULSA

Figure 9.8.4: Seawall along the entire beach boulevard of Pondicherry

Coastal structures: As mentioned earlier, Puducherry town has had seawalls for over 250 years, which have been lengthened and strengthened over time. In addition, bridges have been built across creeks/rivers and in places groynes have been positioned. The table below summarizes the length of various structures in the littoral zone mapped in this project.

Table 9.8.7: Structures surveyed in this study

Structures of Puducherry									
Districts	Breakwater	Bridge	Detached Breakwater	Dock	Elevated Road	Jetty	Pier	Pipe Line	Grand Total
Karaikal	4	-	-	-	-	1	-	-	5
Mahe	-	-	-	-	-	-	-	-	-
Pondicherry	2	-	-	-	-	1	-	-	3
Total Nos.	**6**	**-**	-	**-**	-	**2**	-	-	**8**
Total length of structures (km)	**2.7**	**-**	-	**-**	-	**1.7**	-	-	**4.4**

PHOTO: SVEN ULSA

Figure 9.8.5: Launching a catamaran at a small patch of beach at the Puducherry New Pier

Table 9.8.8: Seawalls & groynes surveyed in this study

Seawalls &Groynes of Puducherry						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Karaikal	-	-	-	-	-	-
Mahe	3	0.6	12.2	9.2	2	4.1
Pondicherry	10	5.8	24.0	32.3	3	1.4
Yanam	-	-	-	-	-	-
Grand Total	**13**	**6.5**	**14.1**	**20.8**	**5**	**5.5**

Ports and harbours: The minor port of Puducherry is situated on the East Coast of India between two major ports of India, namely Chennai and Tuticorin. It is an open roadstead anchorage port situated about 170 kms south of Chennai[119]. It is being developed into a deep water port through private sector participation. However, the plan appears to have run into rough weather, with the most recent news being that the company – Pondicherry Port Limited – has sent a notice to the Puducherry government demanding hefty compensation of Rs. 1,511 crore for what it claims is a violation of the agreement, citing – among other reasons – stalling of the process of obtaining environmental clearance for five years. The development of the port had been severely opposed by environmentalists, who said there would be increased coastal erosion and disappearance of whatever little beach is left, destruction of marine life, loss of livelihood of local fishing communities, and the conversion of farmlands into wastelands, as deep dredging would make the water turn saline[120]. Puducherry also has a fishing harbour under the control of the Fisheries Department.

119 Port Department, Government of Puducherry. http://port.pondicherry.gov.in/location.htm accessed 2 September 2012.

120 Pinto, S. Puducherry Port: Rough weather? http://www.ndtv.com/article/south/puducherry-port-rough-weather-259872. August 28, 2012. http://www.ndtv.com/article/south/puducherry-port-rough-weather-259872 accessed 2 September 2012.

Table 9.8.9: Ports surveyed in this study

Ports & Harbours of Puducherry							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Karaikal	2	1.1	0.5	-	-	-	-
Mahe	1	-	-	-	-	-	-
Pondicherry	2	0.3	0.1	1.0	0.4	1.4	0.5
Yanam	-	-	-	-	-	-	-
Grand Total	**5**	**1.4**	**0.6**	**0.6**	**0.2**	**0.8**	**0.3**

Karaikal has a new port that was commissioned in 2009 by MARG. Located at Vanjore Village, Karaikal Taluk, Puducherry, at a latitude of 10° 50' N and 79° 51', the shoreline of the port falls between 10° 50' 56" N and 10° 49' 44" N. The port is situated between the banks of the Pravadayanar and Vettar rivers. It currently has two breakwaters, and plans are there to extend the breakwaters[121]. According to the NCSCM's assessment, medium erosion is observed on the northern side of Karaikal Port, while medium accretion is observed on the southern side.

Thermal power plant

A gas-based power plant is located in Karaikal. Plans are to expand it.

Table 9.8.10: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	District	Type	Project Name
1	Karaikal	Gas and liquid fuel	Karaikal Gas Turbine Power Station

Among the ten top projects of Puducherry, those related to this study are given in the table[122].

Table 9.8.11: Some of the top ten projects of puducherry

Promoter	Projects	Industry
Pondicherry Port Ltd.	Pondicherry Port Project	Ports
Pondicherry Special Economic Zone Company Ltd.	Special Economic Zone (Sedarapet-Karasur)	SEZ/EPZ
Puducherry Power Corpn. Ltd.	Karaikal Power Project - Expansion	Gas Based Power
Pondicherry Industrial Promotion Devp. & Investment Corpn. Ltd.	IT Park (Kalapet) - Phase II	Software Parks
Government of Union Territory of Puducherry	Fishing Harbour (Mahé) Project	Berths, Jetties

Challenges/issues in the coastal zone: Puducherry's greatest concern is the human-induced erosion of its beaches due to the construction of coastal structures, in particular breakwaters, seawalls and groynes that have been used to build harbours and to protect many of the coastal villages and settlements that are very close to the shoreline. The Puducherry district is the worst affected by human-induced erosion having lost about 25% to 30% of its beaches. In its totality, the U.T. has already lost about 15% to 20 % of its short, 45 km long shoreline. With several projects being proposed along the coast of not only the U.T. but along that of its neighboring states as well, the remaining stretches of the beaches are under serious threat of being damaged and lost (see Case Studies in section 5.6)

121 Karaikal Port. http://www.karaikalport.com accessed 2 September 2012.

122 Puducherry. http://www.projectstoday.com/Sitemap/States/Puducherry.aspx accessed 2 September 2012.

9.9. Andhra Pradesh

Introduction: Andhra Pradesh is India's fourth largest state by area and is the state with the fifth largest by population. The surveyed length of the coastline is about 1,015 km and is detailed in table 9.9.1 below.

Table 9.9.1: Length of coastline

Length of Coastline - Andra Pradesh		
Districts	Length (Surveyed)	Length (Natmo)
East Godavari	169.0	197.0
Guntur	69.9	57.0
Krishna	108.0	128.0
Nellore	169.0	163.0
Prakasam	119.0	117.0
Srikakulam	163.0	158.0
Vishakhapatnam	127.0	127.0
Vizianagaram	30.8	29.0
West Godavari	59.8	11.0
Grand Total	**1015.5**	**987.0**

Two major rivers, Godavari and Krishna, run across the state and form the large Godavari-Krishna delta. The plains to the east of the Eastern Ghats form the coastal plains. Andhra Pradesh has a continental shelf of 33,227 km^2; the average width of the productive continental shelf is 32 km, narrowing from north to south. Visakhapatnam is a large coastal city with a natural harbour and also the headquarters of Eastern Naval Command.[123]. It should also be noted that it is listed in the OECD's list of port cities as being at high risk and vulnerability to extreme climate change events[124].

A study that reports the coastline of the state to be 974 km coast, indicates that 38% is sandy, 3% rocky, 52% mud flats and 7% marshy.

Ecology and biodiversity: Andhra Pradesh has extensive wetlands along the coast. Mangroves, especially of the Coringa sanctuary, have been well studied by the MSSRF in Andhra Pradesh[125]. Extensive mangroves are found in the estuaries of the Godavari and Krishna river systems. Mangroves are also found in patches along the coasts of Visakhapatnam, West Godavari, Guntur and Prakasam districts. Discharge in the river systems has gone down over time due to upstream dams. The Kakinada Bay is an important geomorphological feature which is slowly building up over time. It protects the mangroves from ocean currents and forms a sheltered coastline. A large part of the Godavari wetland comes under the Coringa sanctuary, which includes reserve forests. In the Godavari delta, about 14% of the aquaculture farms have been constructed on mangrove lands located outside the reserve forests. Most of the lands owned privately abutting the mangroves are being converted to shrimp ponds. The study found that while mangroves near villages were degraded due to anthropogenic pressures, and those in the bay were affected by tidal action, accretion in Kakinada bay has increased the area under mangroves. The southern part of Kakinada port was found eroded, but Hope Island was enlarging, extending north and north-west. The bay region has accretions from the north (near Uppulanka) to Gaderu river mouth in Corangi RF extension. Erosion was noticed from the Gaderu river mouth onwards up to the sand bar of Hope Island; also from the end of Hope Island up to the Nilarevu river mouth. In Krishna river delta, aquaculture was being practised both in revenue lands and forest areas. In some places, paddy fields had been converted to prawn farms; in other areas the same farms had been reconverted to paddy fields. Like the Godavari coastline, the Krishna delta too has undergone many changes, starting from Soriagondi at the east end to Nakshatranagar at the west end of the delta. Both erosion and accretion are noticed on the west and east coast of the delta, while considerable accretion has occurred in the southern part. The western part of the delta shows erosion and accretion of both land and mangrove vegetation.

123 Kudale, M.D., 2010. Impact of port development on the coastline and the need for protection. Ind. J. Mar. Sci. 39(4): 597-604.

124 Nicholls, R. J., S. Hanson, C. Herweijer, N. Patmore, S. Hallegatte, J. Corfee-Morlot, J. Chateau, and R. Muir-Wood. (2008), "Ranking Port Cities with High Exposure and Vulnerability to Climate Extremes: Exposure Estimates", OECD Environment WorkingPapers, No. 1, OECD Publishing. doi: 10.1787/011766488208.

125 Ravishankar, T. L. Gnanappazham, R. Ramasubramanian, D. Sridhar, M. Navamuniyammal and V. Selvam. Atlas of Mangrove Wetlands of India. Part 2- Andhra Pradesh. MSSRF, Chennai, 2004.

This study mapped the water bodies as well as protected areas along the coast as given in the tables below.

Table 9.9.2: List of wetlands[126]

Wetlands of Andra Pradesh							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
East Godavari	69	13	-	11	-	-	19
Krishna	68	16	-	14	-	-	39
Nellore	55	14	2	15	-	24	41
Prakasam	8	10	-	13	-	4	8
Srikakulam	3	11	-	7	-	-	6
Visakhapatnam	-	7	-	6	-	-	-
Grand Total	**203**	**71**	**2**	**66**	**-**	**28**	**113**

Table 9.9.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of Andhra pradesh							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
East Godavari	1	13.8	6.9	7.0	7.0	8.2	8.2
Guntur	-	-	-	-	-	-	-
Krishna	-	-	-	-	-	-	-
Nellore	1	27.2	13.6	16.7	16.7	16.1	16.1
Prakasam	-	-	-	-	-	-	-
Srikakulam	-	-	-	-	-	-	-
Visakhapatnam	-	-	-	-	-	-	-
Vizianagaram	-	-	-	-	-	-	-
West Godavari	-	-	-	-	-	-	-
Grand Total	**2**	**41.0**	**20.5**	**0.6**	**4.0**	**0.7**	**0.7**

Table 9.9.4: Water bodies surveyed in this study

Water Bodies of Andhra Pradesh								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
East Godavari	4	7	11.0	7.1	6.2	8.0	5.6	7.2
Guntur	1	3	9.5	11.3	12.6	29.8	16.7	39.7
Krishna	5	9	20.1	8.1	20.1	16.2	15.7	12.6
Nellore	6	14	27.0	7.1	16.0	8.4	16.6	8.7
Prakasam	17	12	21.6	5.9	18.3	10.0	18.5	10.1
Srikakulam	7	10	17.2	4.0	11.2	5.1	10.9	5.0
Visakhapatnam	5	6	7.6	1.8	8.4	4.0	5.9	2.8
Vizianagaram	5	-	0.7	-	0.9	0.1	2.5	0.3
West Godavari	-	-	-	-	-	-	-	-
Grand Total	**50**	**61**	**114.6**	**45.3**	**11.4**	**9.0**	**11.6**	**9.2**

126 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Coastal settlements: This project also mapped the area occupied by the coastal settlements in the zone up to about 500 m from the shoreline. The district-wise information is presented in the table below. This table is followed by one that gives the district-wise space in the 500 m zone occupied by commercial activities.

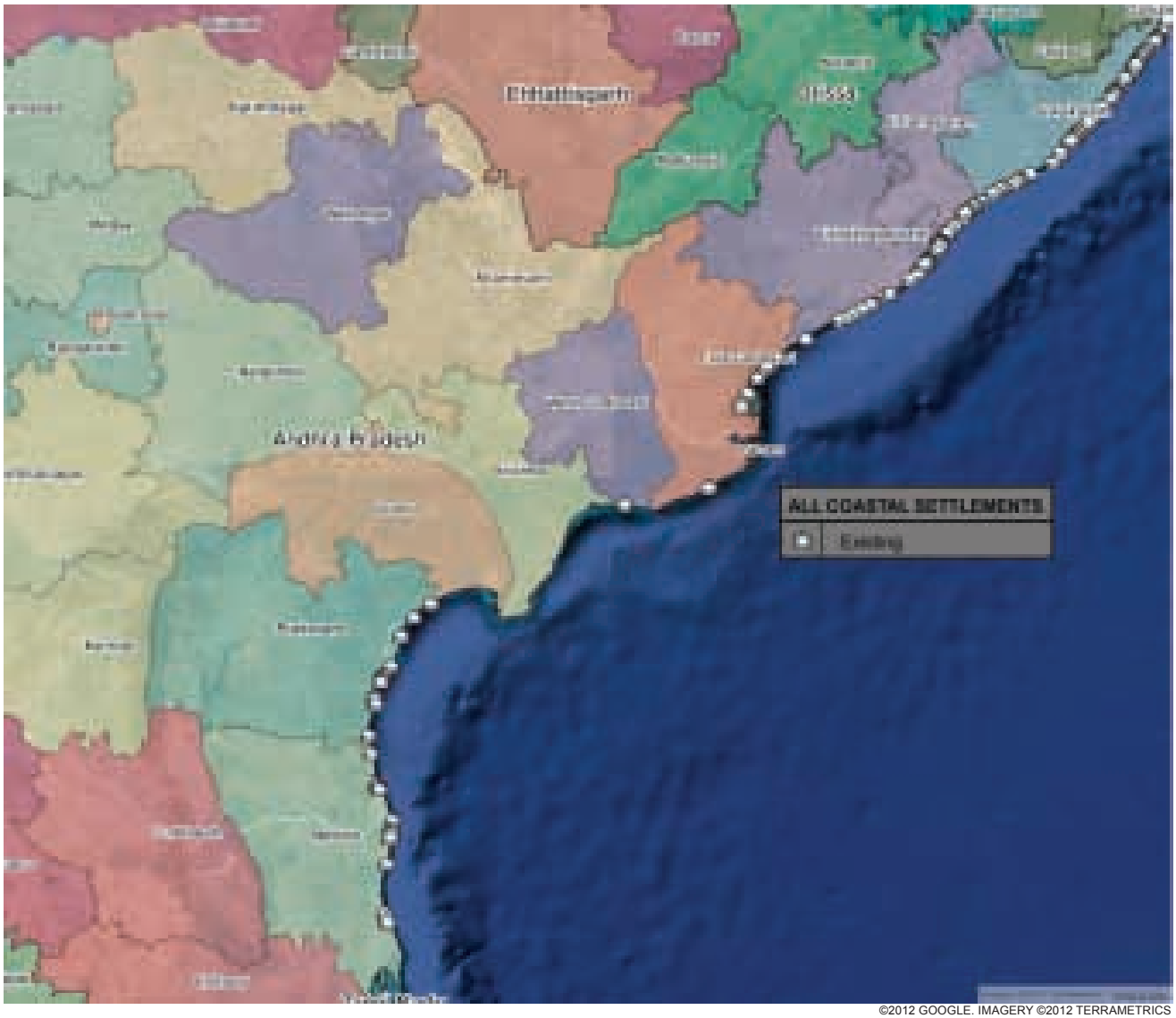


Figure 9.9.1: Settlements

Table 9.9.5: Settlements surveyed in this study

Settlements of Andra Pradesh							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
East Godavari	14	7.8	1.6	4.6	1.9	4.0	1.7
Krishna	1	0.8	0.2	0.8	0.3	0.6	0.2
Nellore	14	7.9	1.3	4.7	1.5	4.9	1.6
Prakasam	15	6.9	1.7	5.8	2.8	5.9	2.9
Srikakulam	79	29.7	4.3	18.2	5.2	18.8	5.4
Visakhapatnam	31	53.0	6.1	41.7	9.6	41.7	9.6
Guntur	-	-	-	-	-	-	-
Vizianagaram	-	-	-	-	-	-	-
West Godavari	-	-	-	-	-	-	-
Grand Total	**154**	**106.2**	**15.1**	**10.5**	**3.0**	**10.8**	**3.1**

Table 9.9.6: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
Srikakulam	128	25,579	25,274	25,295	98,450
Vizianagaram	20	5,138	5,137	5,134	20,812
Visakhapatnam	63	28,779	28,738	28,118	113,632
East Godavari	97	44,476	43,800	43,021	165,208
West Godavari	7	2,451	2,438	1,350	9,188
Krishna	43	13,073	13,061	13,040	43,005
Guntur	36	11,771	10,492	11,650	39,333
Prakasam	67	15,103	15,055	14,530	51,511
Nellore	94	17,057	17,044	16,963	64,289
Andhra Pradesh	555	163,427	161,039	159,101	605,428

Fishing: The total marine fish production of Andhra Pradesh for 2010 was 253,000 tonnes, with a slight reduction of only 0.5% from 2009[127]. The mechanized, motorized and non-mechanized sectors contributed 48.3%, 37.8% and 13.9% respectively. According to the report, from late 2008 onwards there has been a change in mode of tuna exploitation at Pudimadaka and Kakinada. Earlier, the fishermen left for fishing in the early hours by sail boats and returned only by night with low catch. The advent of oil drilling by Reliance at Kakinada heralded the use of large lights by the drilling rigs, which were found to attract yellowfin tuna in large numbers. Now, the pattern of fishing has changed to fishing at night/early hours. A summary of the population of the fishing community from the 2010 CMFRI census is given below. A comparison of the fisher population with the total population of the district has been graphically represented in the chart.

Table 9.9.7: Commercial areas surveyed in this study

Commercial Areas of Andra Pradesh							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
East Godavari	51	32.8	10.8	19.4	12.8	16.7	10.9
Guntur	13	5.4	2.6	7.8	7.4	9.5	9.1
Krishna	9	0.9	0.7	0.8	1.3	0.7	1.1
Nellore	67	37.1	21.0	22.0	24.9	22.8	25.8
Prakasam	51	30.4	9.3	25.5	15.7	26.0	15.9
Srikakulam	84	57.9	3.2	35.5	3.9	36.7	4.0
Visakhapatnam	103	32.5	31.8	25.6	50.1	25.6	50.1
Vizianagaram	31	4.7	0.7	15.3	4.4	16.3	4.7
West Godavari	2	0.1	0.1	0.2	0.2	1.3	0.9
Grand Total	**411**	**201.9**	**80.1**	**19.9**	**15.8**	**20.5**	**16.2**

127 CMFRI Annual Report 2010-11.

Shoreline change: The length of the coast affected by erosion was given as 9.19 km in 2004, but by 2009 (just 5 years later) the figure had gone up by over seven times to 65.7 km. Of this, about 20.45 km are protected.

Uppada on the coast of Andhra Pradesh has seen severe erosion. A fishing village in the East Godavari district, it had a wide open beach till about 20 years ago. Since then large scale erosion has resulted in the entire village, four ancient temples, a play-ground and hundreds of acres of land being annexed by the sea[128].

PHOTOS: S.B. SARMA

a) erosion of village

b) a closer view

Figure 9.9.2: Fishing village of Uppada (2008)

In 2010, IIT Madras tried using geotubes about a kilometre from Uppada coast. Apparently successful, they plan to extend them for another three km[129].

According to the BMTPC's vulnerability atlas, the entire coast of Andhra Pradesh is listed as coming under very high damage risk zone with respect to wind and cyclones. While Srikakulam and Visakhapatnam districts (northern AP) come under Zone II or low risk from earthquakes, the rest of the coast comes under Zone III or at moderate risk from earthquakes. Almost every year, some part of coastal Andhra Pradesh is affected because of landfall by a cyclone.

PHOTO: S.B. SARMA

Figure 9.9.3: Attempts to save Uppada's shore using RCC blocks

128 S.B. Sarma, personal communication, 8 August 2008.

129 Mariappan, Julie. IIT-Madras's geo-tubes to check coastal erosion in Andhra Pradesh. The Times of India. 7 May 2012. http://articles.timesofindia.indiatimes.com/2012-05-07/the-good-earth/31610123_1_geo-tubes-iit-m-iit-madras accessed 2 September 2012.

Coastal structures: Piers, breakwaters, detached breakwaters, jetties, groynes, seawalls, pipelines, etc, are the major structures seen in the coastal zone. A summary of structures in the littoral zone mapped in this project is given in the table.

Table 9.9.8: Structures surveyed in this study

Structures of Andhra Pradesh									
Districts	Breakwater	Bridge	Detached breakwater	Dock	Elevated road	Jetty	Pier	Pipeline	Total Nos.
East Godavari	-	-	1	2	-	-	-	-	3
Guntur	-	-	-	-	-	-	-	-	-
Nellore	4	-	-	-	-	4	3	1	12
Prakasam	-	-	-	-	-	1	1	-	2
Srikakulam	2	-	-	-	-	1	1	-	4
Visakapatnam	3	-	1	-	-	-	3	-	7
Total Nos.	**9**	-	**2**	**2**	-	**6**	**8**	**1**	**28**
Total Length of Structures (km)	**6.7**	-	**2.6**	**1.4**	-	**1.0**	**2.3**	**0.5**	**17.5**

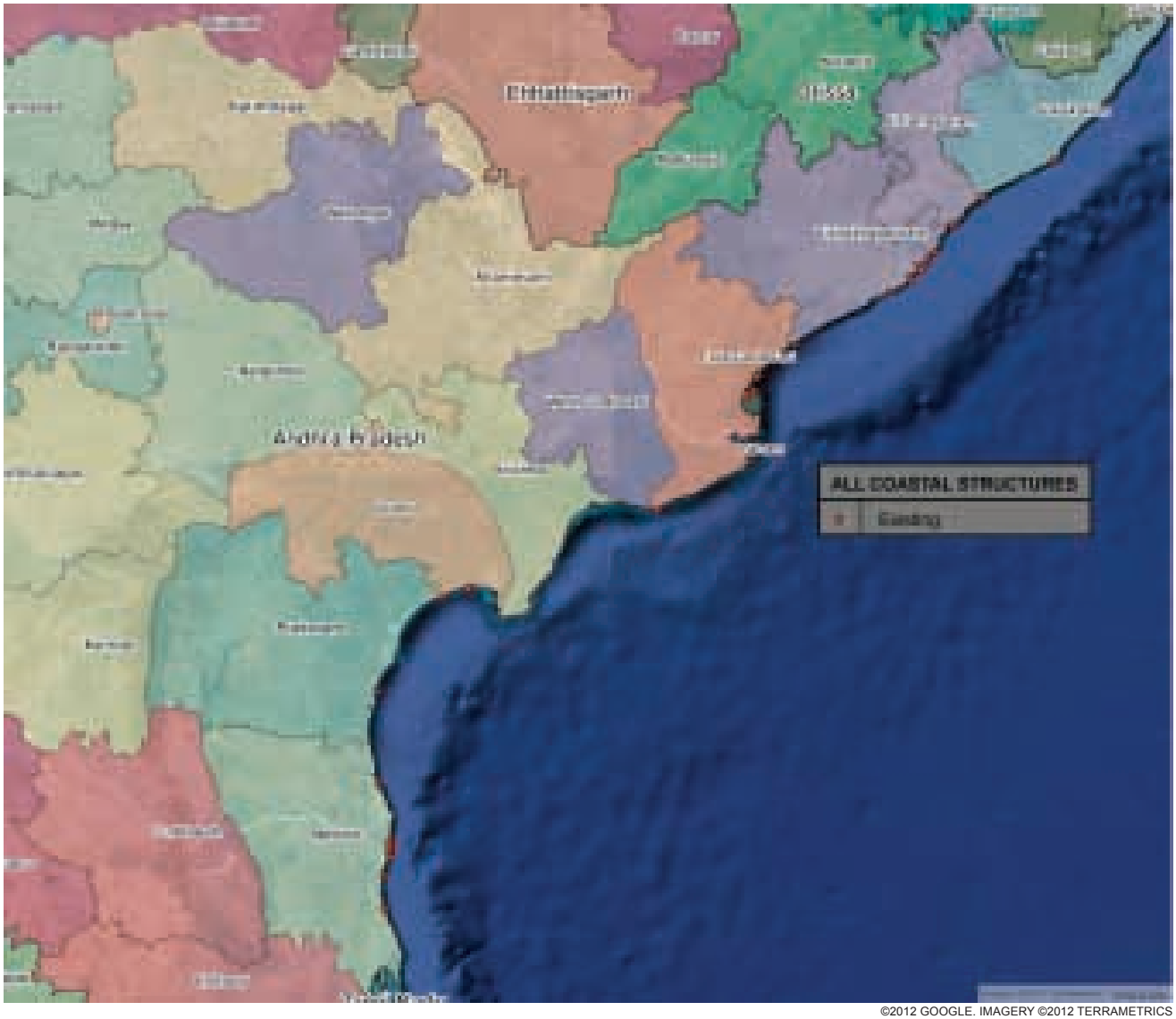


Figure 9.9.4: Structures

Table 9.9.9: Seawalls & groynes surveyed in this study

Seawalls & Groynes of Andhra Pradesh						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
East Godavari	3	3.5	2.1	1.8	2	0.9
Guntur	-	-	-	-	2	0.2
Krishna	-	-	-	-	-	-
Nellore	-	-	-	-	-	-
Prakasam	-	-	-	-	-	-
Srikakulam	-	-	-	-	-	-
Visakhapatnam	1	0.2	0.2	0.2	1	0.1
Vizianagaram	-	-	-	-	-	-
West Godavari	-	-	-	-	-	-
Grand Total	4	3.7	0.4	0.4	5	1.0

Ports and harbours: Andhra Pradesh presently has 14 notified non-major ports and one major port (Visakhapatnam). The 14 notified non-major ports are Bhavanapadu, Meghavaram, Kalingapatnam, Bheemunipatnam, Gangavaram, Nakkapalli, Kakinada SEZ, Kakinada, S.Yanam, Narsapur, Machilipatnam, Nizampatnam, Vadarevu and Krishnapatnam. Krishnapatnam is the first greenfield port of Andhra Pradesh. Visakhapatnam has a natural harbour because of the presence of a headland and narrow beaches. Despite the construction of breakwaters, the use of sand nourishment by bypassing the sand from a jetty using shore-connected pipeline has proved successful. But this clearly requires prior studies, judicious and careful planning of dredging operations, and continuous monitoring.

This study mapped the area occupied by each port in the littoral zone, and the information is presented in the table below.

Table 9.9.10: Ports surveyed in this study

Ports & Harbours of Andhra Pradesh							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
East Godavari	3	1.6	1.1	1.0	1.3	0.8	1.1
Guntur	1	0.1	-	0.1	0.1	0.2	0.1
Krishna	1	0.1	0.1	0.1	0.1	0.1	0.1
Nellore	1	0.8	0.6	0.5	0.7	0.5	0.7
Prakasam	1	0.4	-	0.4	0.1	0.4	0.1
Srikakulam	2	0.6	0.1	0.3	0.1	0.4	0.1
Visakhapatnam	4	2.0	0.6	1.5	1.0	1.5	1.0
Vizianagaram	-	-	-	-	-	-	-
West Godavari	-	-	-	-	-	-	-
Grand Total	13	5.6	2.5	0.6	0.5	0.6	0.5

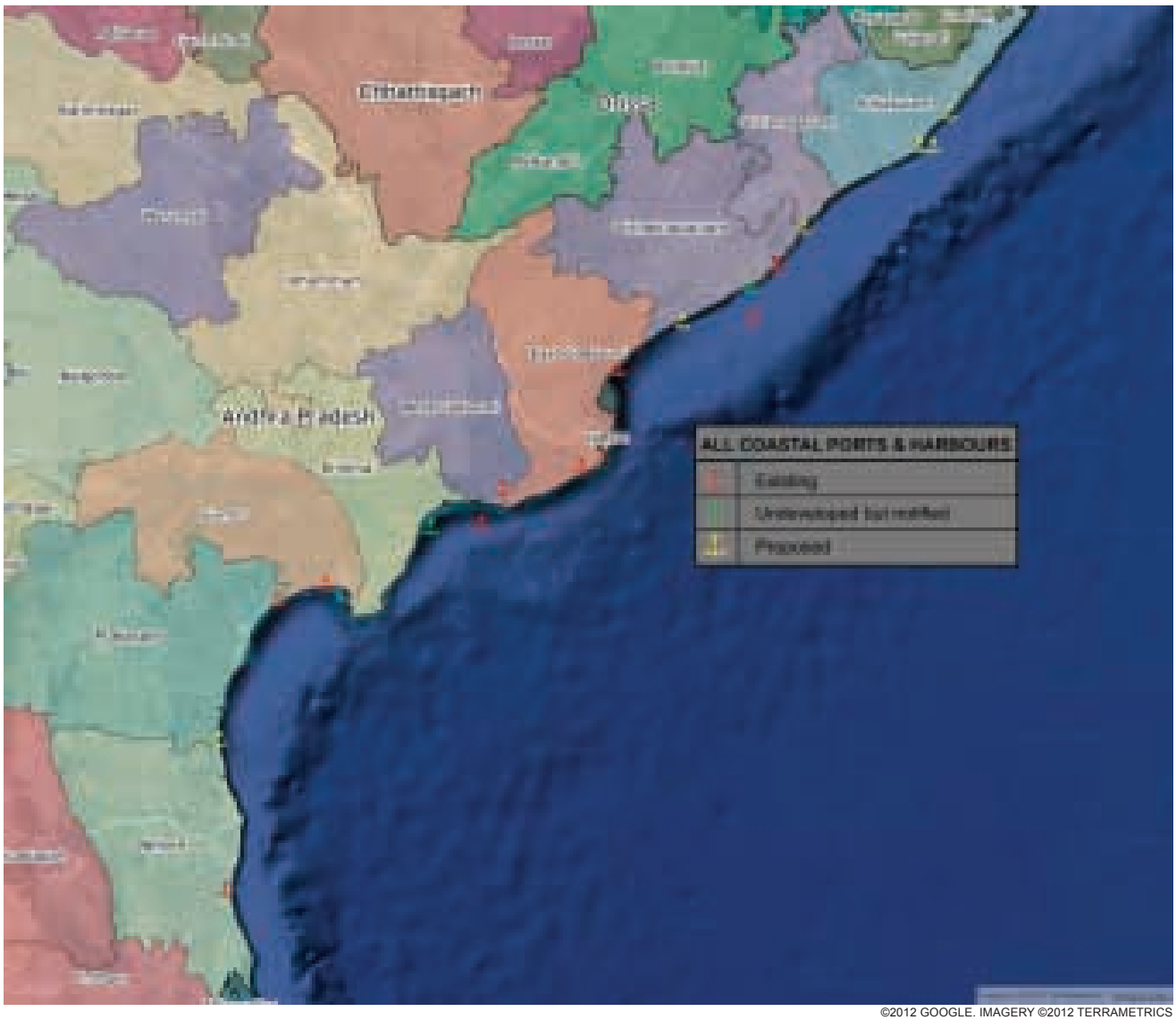


Figure 9.9.5: Ports

Table 9.9.11: Proposed ports

Proposed ports		
No. of ports State	**District**	**Total**
Andhra Pradesh		
	East Godavari	1
	Guntur	1
	Prakasam	2
	Srikakulam	2
	Srikakulam	1
	Visakapatnam	1
	Visakhapatnam	1
	West Godavari	1
Total		**10**

Thermal power plants: According to a very recent report[130], fifteen new thermal power projects are coming up in the private sector, leading to a capacity addition of 24,120 MW to the State's grid. Krishnapatnam area in Nellore district has been chosen for locating eight of the 15 new private projects, as the port there will facilitate the import of coal. The 15 private plants are East Coast Energy 1,320 MW (Srikakulam district), Alfa Infraprop 1,320 MW (Vizianagaram), Simhapuri Energy 600 MW (Nellore), Meenakshi 2,320 MW, Thermal Power Tech 1,980 MW, Krishnapatnam Power Corporation 2,860 MW, Kineta Power 1,980 MW (all Krishnapatnam), Nelcast Energy Corporation 1,320 (Nellore), Navabharat Energy 300 MW, Coastal Projects 300 MW (both Khammam district), NSL Andhra Power 1,600 (Krishna district), Srinivasam Electric Power 1,320 MW (Visakhapatnam), Weispun Energy 1,320 MW, MSR India 300 (both Prakasam district) and GVK Energy Ventures 5,280 MW (six locations in State).

Table 9.9.12: Coastal thermal power plants

Existing power plants - coastal			
Sl.No	**District**	**Type**	**Project Name**
1	East Godavari	Gas and liquid fuel	Spectrum Combined Cycle Power Plant
2	Visakhapatnam	Thermal-coal	Simhadri Super Thermal Power Plant

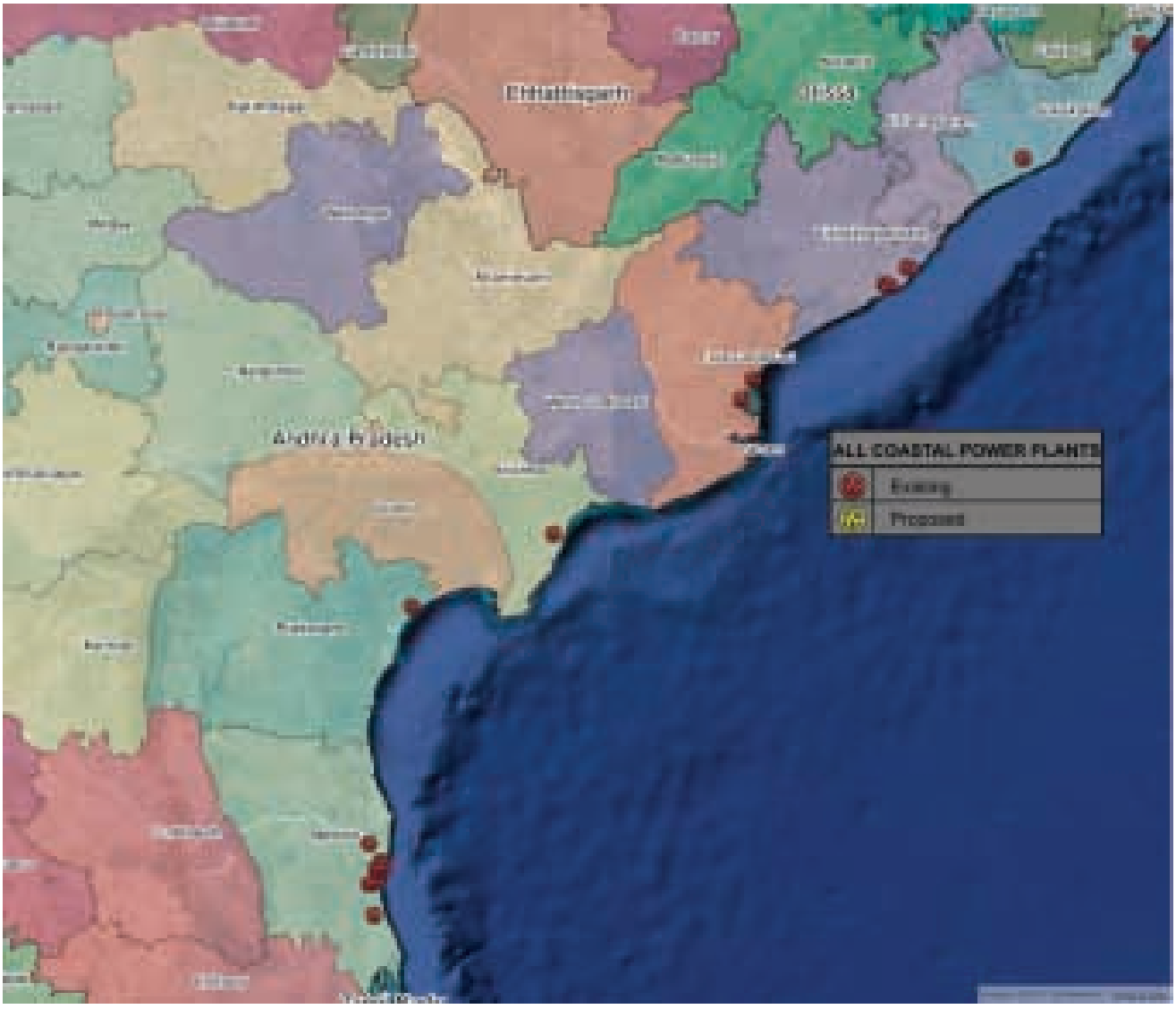


Figure 9.9.6: Power plants

130 15 thermal projects to add 24,120 MW to State grid. The Hindu, Hyderabad, 28 August 2012.

In addition to these, there are 6 proposed power plants with incorrect coordinates, 6 with no coordinates provided, 8 with coordinates the same as other power plants, and 10 which are more than 10 km from the coast.

Specific mention needs to be made of the struggle against thermal power plants in Srikakulam district. Nagarjuna Construction Company (NCC) was to build a 1,980 MW coal-based thermal power project at Sompeta. Though the state government maintained that the proposed site for the power project in Sompeta was wasteland, it is in fact part of a 20 km-long unique, fertile coastal wetland system that stretches through Sompeta, Kanchili and Kaviti blocks, spreading over 1,619 ha. Thirty villages in these three blocks depend on these wetlands for their living. The swamp supports over 200,000 people, including farmers, fishers and artisans, and is rich with biodiversity. Stiff opposition by locals resulted in violence and police firing that killed two people on 14 July 2010. Subsequently the environmental clearance for the project was suspended by the MoEF[131].

Table 9.9.13 Proposed thermal power plants

Proposed power plants - coastal					
	Fuel	**District**	**Village**	**Company**	**Ownership**
1	Gas	East Godavari	Komaragiri	Athena Power	Private
2	Coal	Nellore	Krishnapatnam	Andhra Pradesh Power Development Company Ltd	State
3	Coal	Nellore	Tamminapatnam and Momidi	Reliance - Krishnapatnam Power Corporation Limited	Private
4	Coal	Nellore	Thamminapatnam	Simhapuri Energy Pvt. Ltd.	Private
5	Coal	Nellore	Krishnapatnam	Reliance - Coastal Andhra Power Ltd.	Private
6	Coal	Nellore	Krishnapatnam	Kineta Power Pvt. Ltd.	Private
7	Coal	Nellore	Thammenapatriam	Meenakshi Energy Private Ltd.	Private
8	Coal	Nellore	Painampuram	Thermal Powertech (India) Ltd.	Private
9	Coal	Nellore	Momidi	Lanco - Pragdisa Power Pvt. Ltd.	Private
10	Coal	Prakasam	Kanuparthi	APPDCL	State
11	Coal	Srikakulam	Sompeta Mandal	Nagarjuna Construction Co. Ltd.	Private
12	Coal	Visakhapatnam	Nakkapalli Mandal	Suryachakra Thermal Energy (Andhra) Pvt. Ltd.	Private
13	Gas	Visakhapatnam	Revu Polavaram	Athena - East Coast Energy Pvt. Ltd.	Private

East Coast Energy Pvt Ltd's coal-based thermal power plant is to come up in Kakrapalli with an investment of Rs. 12,000 crore on 992 ha of land provided by the Andhra Pradesh Industrial Investment Corporation (APIIC). The EIA declared the area as barren, hence not requiring resettlement, and belonging to the state. It is actually common property on which thousands of people's livelihoods depend. In August 2010, the authority cleared the project with conditions, saying it was "balancing development with conservation", and asked that a portion of the land allocated be retained as wetland. This clearly indicated that the land is not barren[132]. On 28 February 2011, police fired on protestors and two people were killed. Following the clash the Union Ministry of Environment and Forests directed the company on March 1st to suspend work at Kakarapalli. The ministry also ordered the Expert Appraisal Committee dealing with thermal power projects to examine whether the project site was a wetland and whether the company adhered to conditions of the environmental clearance given in April 2009. This would be the second such enquiry. The protest still goes on[133].

131 MoEF, 2010. Letter no. F. No. J-13012111912008-IA-II (T). dated 15 July 2010. http://moef.nic.in/downloads/public-information/ncc_letter.pdf accessed 2 September 2012.

132 Mahapatra, Richard. The great wetland robbery in Kakarapalli. Down to Earth, 15 April 2011.

133 Senthalir, S. Kakarapalli locals cold to promises of thermal power. Postnoon, 7 August 2012. http://postnoon.com/2012/08/07/kakarapalli-locals-cold-to-promises-of-thermal-power/64529

Special Economic Zones: Andhra Pradesh has 70 SEZs proposed in 15 districts. For these a staggering 5 million acres stretching over 1,575 km^2 are to be acquired for SEZs in coastal districts, with a coastal corridor that will include airports, sea ports, ship-breaking, pharmaceutical, petrochemical, information technology, apparel units and captive thermal power stations. SEZs are aimed to promote IT, pharma, petrochemical, textile and multiproduct industries. Among the coastal districts, Visakhapatnam tops the list with 9 SEZs, followed by 4 in Nellore, 3 in East Godavari, 2 each in Krishna and Guntur, and 1 in Prakasam districts[134]. Two of the largest operating SEZs are APIIC's 2,206 ha SEZ in Visakhapatnam and the Kakinada SEZ's 1,035 ha[135]. According to the CAG report for the year ending 31 March 2011 the state exchequer suffered a revenue loss of Rs. 1,784 crore on account of allotment of government land to private investors at abysmally low rates. A total of 35,811 ha was allotted to 1,027 beneficiaries in an ad hoc and arbitrary manner during this period for various purposes, including industrial development, ports and housing[136].

9.10. Odisha

Odisha (Orissa) is the 9th largest state by area in India, and the 11th largest by population. The total area of the state is 155,707 km^2, which is about 4.74% of the Indian land mass. The length of the coastline surveyed is about 515 km along the Bay of Bengal and is detailed in the table below.

Table 9.10.1: Length of coastline

Length of Coastline - Andra Pradesh		
Districts	Length (Surveyed)	Length (Natmo)
East Godavari	169.0	197.0
Guntur	69.9	57.0
Krishna	108.0	128.0
Nellore	169.0	163.0
Prakasam	119.0	117.0
Srikakulam	163.0	158.0
Vishakhapatnam	127.0	127.0
Vizianagaram	30.8	29.0
West Godavari	59.8	11.0
Grand Total	**1015.5**	**987.0**

The rivers Mahanadi, Brahmani and Baitarani course through it and form deltas. The state is known for the Chilika Lagoon, a brackish water lagoon which is the largest coastal lagoon in India and second largest in the world. Odisha has abundant natural resources – a fifth of India's coal, a quarter of its iron ore, a third of its bauxite reserves, and most of its chromite.

57% of Odisha's coast is sandy, 53% mudflats and 10% marshy.

Ecology and biodiversity: The coast of Odisha is best known for Chilika Lake with its unique brackish-water ecology, the largest wintering ground for migratory bird species in the Indian subcontinent. The coast is also known for mass nesting of turtles, specifically the Olive Ridleys. Though the Olive Ridley sea turtles nest at several sites in the western Indian Ocean, Indian subcontinent and Southeast Asia, the single most important breeding area for them in the Indian Ocean along the Bay of Bengal is Odisha, especially at Gahirmatha, Rushikulya, Devi and Dhamara river mouths. The annual arrival of turtles on the beaches is awaited with eagerness and concern by wildlife enthusiasts. In March 2012, according to forest officials, an estimated 46,000 female turtles were spotted

134 C.M. Muralidharan, personal communication.

135 Intercultural Resources. Five Years of SEZ Act. A citizen's report card on special economic zones. http://sanhati.com/wp-content/uploads/2010/11/five-years-of-sez-act.pdf

136 Suchitra, M. CAG exposes land scam in Andhra. Down to Earth, 30 March 2012.

digging pits on the sandy nesting ground for laying eggs. At the same time last year, the numbers were ten times as much[137]. In nearby Rushikulya river mouth, a large number of eggs of Olive Ridley turtles were destroyed due to sea erosion, just ahead of the hatching. Reportedly, instead of their traditional site, the Olive Ridley turtles had nested in a new site, measuring about two-km near the river mouth. The new site is like an island and very vulnerable to sea erosion[138].

Table 9.10.2: List of wetlands[139]

Wetlands of Odisha							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
Baleswar	8	-	-	12	-	-	39
Bhadrak	19	-	-	3	-	-	11
Ganjam	-	-	1	8	-	-	22
Jagatsinghpur	33	-	-	11	-	-	73
Kendrapara	103	-	-	20	-	-	103
Khordha	-	-	2	-	-	-	
Puri	-	-	4	18	-	-	70
	163	-	7	72	-	-	318
Grand Total	**163**	**0**	**7**	**72**	**0**	**0**	**318**

This study mapped the coastal water bodies of Odisha, and the extent found within the 500 m zone is given in the table.

Table 9.10.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of Odisha							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Baleshwar	-	-	-	-	-	-	-
Bhadrak	-	-	-	-	-	-	-
Ganjam	-	-	-	-	-	-	-
Jagatsinghpur	-	-	-	-	-	-	-
Kendrapara	2	43.3	21.6	42.4	42.4	47.0	47.0
Khordha	-	-	-	-	-	-	-
Puri	2	59.7	29.8	70.7	70.7	60.3	60.3
Grand Total	**4**	**102.9**	**51.5**	**19.9**	**19.9**	**21.5**	**21.5**

Bhitarkanika, a hot-spot of biodiversity, is home to the largest population of giant salt water crocodiles in India. It is the second largest viable mangrove eco-system in India, harbouring more than 70 species of mangrove eco-system in India, harbouring more than 70 species of and its associates, and was declared a Ramsar site in 2002. Gahirmatha is a marine wildlife sanctuary of Odisha notified in 1997. The protected areas along the coast were mapped and are given in the table below.

137 Olive Ridley turtles start spawning on Odisha beach. The Times of India. 22 March 2012. http://articles.timesofindia.indiatimes.com/2012-03-22/flora-fauna/31224741_1_olive-ridley-turtles-gahirmatha-beach-female-turtles

138 Sea erosion in Odisha destroys Olive Ridley turtle eggs. Daily News and Analysis. 12 April 2012. http://www.dnaindia.com/india/report_sea-erosion-in-Odisha-destroys-olive-ridley-turtle-eggs_1674145

139 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

PHOTO: DEBI GOENKA

Figure 9.10.1: Mangroves in Bhitarkanika.

Table 9.10.4: Water bodies surveyed in this study

Water Bodies of Odisha								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Bhadrak	-	-	-	-	-	-	-	-
Ganjam	2	4	11.1	3.2	17.5	10.2	23.2	13.5
Kendrapara	2	2	2.7	2.8	2.7	5.5	3.0	6.0
Puri	3	6	35.0	12.0	41.4	28.5	35.3	24.3
Baleshwar	3	7	10.8	6.0	12.0	13.4	11.5	12.8
Jagatsinghpur	2	1	6.8	1.9	12.3	6.9	15.4	8.7
Khordha	-	-	-	-	-	-	-	-
Grand Total	**12**	**20**	**66.4**	**26.0**	**12.8**	**10.0**	**13.9**	**10.8**

PHOTO: DEBI GOENKA

Figure 9.10.2: A crocodile in the mangroves, Bhitarkanika.

Coastal settlements: This project also mapped the area occupied by coastal settlements in the zone up to about 500 m from the shoreline. The district-wise information is presented in the table below.

Table 9.10.5: Settlements surveyed in this study

Settlements of Odisha							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Bhadrak	5	8.1	1.7	15.8	6.5	19.3	7.9
Kendrapara	2	3.3	1.0	3.2	2.0	3.6	2.2
Puri	15	16.4	4.7	19.4	11.2	16.5	9.5
Ganjam	9	5.5	1.2	8.6	3.7	11.4	4.9
Baleshwar	18	27.2	6.3	30.4	14.0	29.0	13.3
Jagatsinghpur	11	6.3	1.3	11.4	4.5	14.3	5.7
Khordha	-	-	-	-	-	-	-
Grand Total	**60**	**66.7**	**16.1**	**12.9**	**6.2**	**13.9**	**6.7**

Table 9.10.6: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
Baleshwar	415	47,162	30,150	27,633	270,675
Bhadrak	95	12,765	11,856	5,503	64,574
Kendrapara	117	13,527	6,419	5,571	76,361
Jagatsinghpur	119	17,508	17,105	6,750	94,812
Puri	41	14,675	13,428	7,401	63,829
Ganjam	26	8,601	8,583	3,421	35,263
Total	813	114,238	87,541	56,279	605,514

Fishing: The provisional amount of marine fish landed in Odisha in 2008-09 is estimated to have been 135,487 tonnes out of a total of 374,822 tonnes. The highest production comes from the inland sector[140]. A summary of the population of the fishing community from the 2010 CMFRI census is given below.

Table 9.10.7: Commercial Areas surveyed in this study

Commercial Areas of Odisha							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Bhadrak	4	2.1	1.9	4.1	7.3	5.0	8.9
Ganjam	39	8.3	1.5	13.1	4.6	17.3	6.1
Kendrapara	2	1.8	1.1	1.8	2.2	2.0	2.5
Puri	44	7.1	0.9	8.4	2.2	7.1	1.9
Baleshwar	21	3.1	0.7	3.5	1.6	3.3	1.5
Khordha	-	-	-	-	-	-	-
Jagatsinghpur	20	5.4	9.1	9.7	33.1	12.2	41.5
Grand Total	**130**	**27.8**	**15.2**	**5.4**	**5.9**	**5.8**	**6.4**

Tourism is also of great importance in Odisha, especially to the famous Jagannath Temple at Puri and the Sun Temple at Konarak. Rampant construction on the beach for tourism has resulted in extensive beach erosion in Puri. This study also mapped commercial areas in the space within the 500 m zone from the shore as given in the table below. As can be seen, a large percentage of the area in Jagatsinghpur is associated with commercial activities, which is not surprising considering that both Paradip port and POSCO are located there.

Shoreline change: According to the National Assessment of Shoreline Change for Odisha[141], of the 480 km length of the coast 39 km or 8% of the coast is subject to high erosion and 9.8 km or 2% is to be considered artificial, as it has seawalls/riprap. The assessment indicated that the coast of Odisha is largely accreting (47%) and 14% is stable. Erosion (high, medium and low level) affects 37% of the coast. Accretion is dominant in the central and northern part, while erosion dominates the southern part of the coast.

Most of Odisha's coast falls in the very high damage risk zone for cyclones and wind. While most of it falls in Zone II low damage risk zone for earthquakes, Baleshwar as well as the section between Kendrapara and Jagatsinghpur fall in Zone III – moderate damage risk zone.

A Coastal Vulnerability Index (CVI) was prepared for Odisha coast[142] based on eight relative risk variables. It showed that 76 km of the coastal stretch of the state, covering parts of Ganjam, Chilka, southern Puri and Kendraparha, comes under low vulnerability. About 297 km covering northern Ganjam, Chilika, central Puri,

140 Fisheries Statistics. Odisha. http://www.Odishafisheries.com/File/updated/Fish_statistics.pdf

141 Ramesh, R., Purvaja, R and Senthil Vel, A. Shoreline Change Assessment for Odisha Coast. www.ncscm.org

142 Srinivasa Kumar, T., R. S. Mahendra, Shailesh Nayak, K. Radhakrishnan, and K. C. Sahu. Coastal Vulnerability Assessment for Odisha State, East Coast of India. (2010) Coastal Vulnerability Assessment for Odisha State, East Coast of India. Journal of Coastal Research: Volume 26, Issue 3: pp. 523 – 534. doi: http://dx.doi.org/10.2112/09-1186.1

Jagatsinghpur, Kendrapara, southern Bhadrak and northern Baleshwar is medium vulnerable. About 107 km covering northern Puri, parts of Jagatsinghpur, Kendraparha, northern and southern Bhadrak and southern Baleshwar is highly vulnerable.

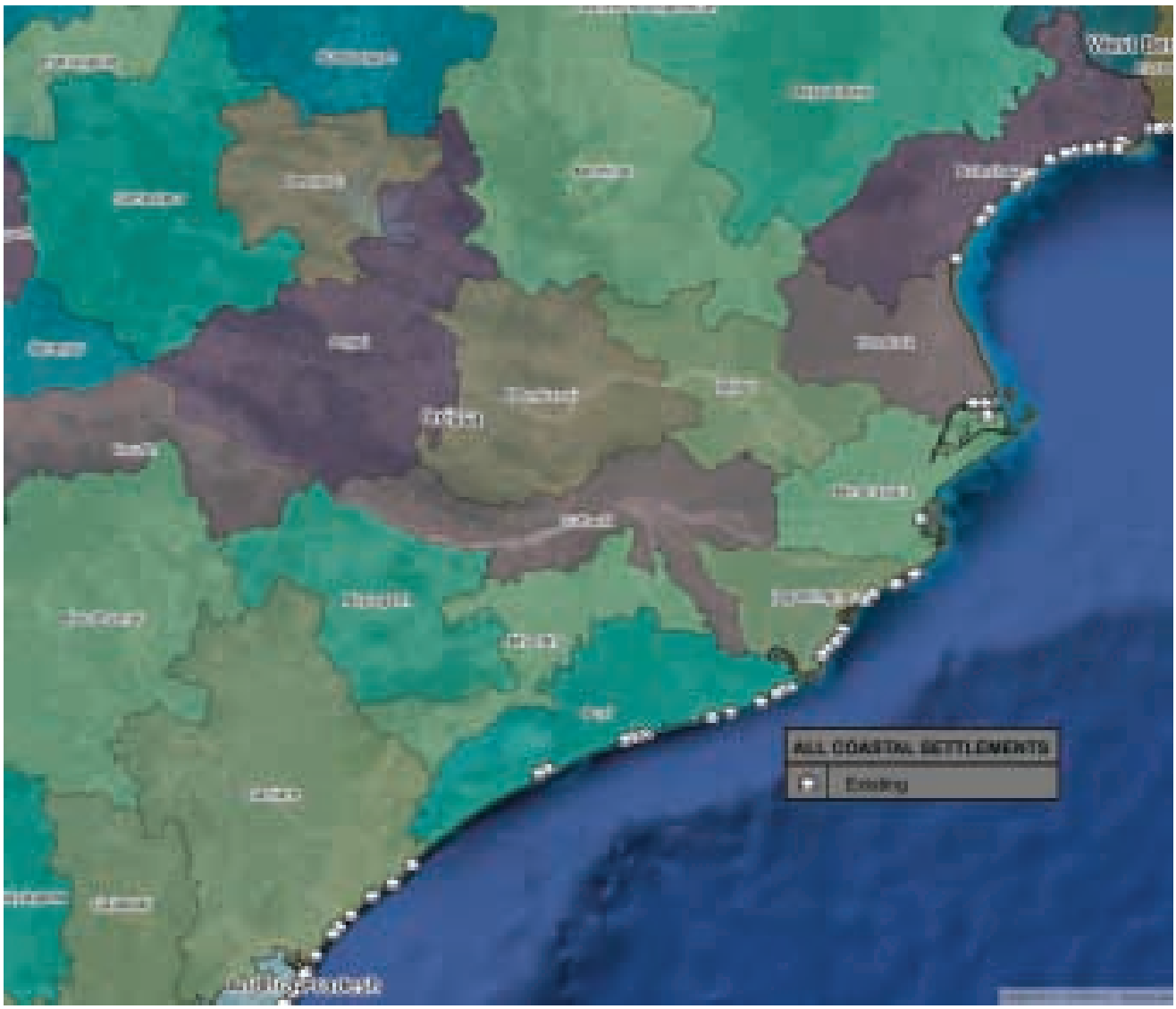


Figure 9.10.3: Settlements

Coastal structures: Coastal structures in Odisha are mainly seawalls, breakwaters, docks and bridges. A summary of structures in the littoral zone mapped in this project is given in the table. According to the CPDAC (Table 8.7), 10 km of the coastline was protected; updated information after 2004 was not available. This study measured seawalls to an extent of about 22 km.

Table 9.10.8: Structures surveyed in this study

Structures of Odisha									
Districts	Breakwater	Bridge	Detached breakwater	Dock	Elevated road	Jetty	Pier	Pipe line	Grand Total
Baleshwar	-	1	-	1	-	-	-	-	2
Ganjam	-	-	-	-	-	1	-	1	2
Puri	2	-	-	-	-	-	-	-	2
Total Nos.	**2**	**1**	-	**1**	-	**1**	-	**1**	**6**
Total Length of Structures (km)	**1.2**	**0.3**	-	**0.8**	-	**0.5**	-	**0.4**	**3.2**

Figure 9.10.4: Structures

Table 9.10.9: Seawalls & groynes surveyed in this study

Seawalls &Groynes of Odisha						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
Baleshwar	6	4.5	5.0	4.7	-	-
Bhadrak	-	-	-	-	-	-
Ganjam	7	12.4	19.5	25.8	1	0.5
Jagatsinghpur	-	-	-	-	-	-
Kendrapara	-	-	-	-	-	-
Khordha	-	-	-	-	-	-
Puri	3	5.1	6.0	5.1	1	0.4
Grand Total	**16**	**21.9**	**4.2**	**4.6**	**2**	**1.0**

Ports and harbours: Odisha is on a fast-track with respect to development of ports. Paradip is Odisha's major port. The port is now equipped with 14 berths, one single point mooring, one Ro-Ro Jetty, one turning circle commonly known as a turning basin, with 250 meters diameter, well maintained approach channel and

entrance channel having draught of 15 metres and 13 metres respectively. In 2009-10, the port handled 57.01 million tonnes. According to the business plan for the port, it faces stiff competition from Dhamra and emphasises the importance of connectivity for port health. The report says that 70% of land is already used and that future expansion may require more space, even swallowing the township[143]. Paradip port has resulted in the erosion of the coastline due to the construction of breakwaters. A sand pump was installed south of the southern breakwater to pump the accumulating material to the eroding northern side. However, there were problems operating the pumps, and the trestle was damaged in a cyclone in 1972. A seawall of about 5 km length was constructed, which contained to some extent the landward encroachment of the sea but has resulted in the shifting of the -3m and -5m contours[144].

In addition there is the fairweather port of Gopalpur, and recently a port has been established at Dhamra. The Dhamra port proposed a power plant/chemical plant or fertilizer plan within its port limits. A critique of the Dhamra port by Greenpeace[145] pointed out inconsistencies in the report, starting with the fundamental data on port capacity, for which different values were given in the environmental clearance report, the detailed project report, and the company website. This may appear trivial to an outsider, but this is what determines the size of ships entering the port. Similarly, it is pointed out that while the EIA is based on a given project location, the actual location is different. There are many such issues, and overall it highlights the inadequacy of the impact assessment.

PHOTO: DEBI GOENKA

Figure 9.10.5: Dhamra port.

143 TransCare Logistics India Pvt. Ltd., 2007. Business Plan Development for the Paradip Port Trust – Final Report.

144 Kudale, M.D., 2010. Impact of port development on the coastline and the need for protection. Ind. J. Mar. Sci. 39(4): 597-604.

145 Johnston, Paul & David Santillo. The Dhamra-Chandbali Port Expansion Project, Odisha, India. Critique of the Environmental Impact Assessment. Greenpeace India, Bangalore, May 2007.

The Government of Odisha has initiated a policy of leasing government land for execution of infrastructure projects and port projects on a BOT basis[146]. As per the port policy (2004), 13 locations were notified for the development of ports. A 14th port was to be notified at Talasara[147]. This deep water port proposed by JSW Group would actually have excess capacity, which could be used by others.

The state government had got into trouble after signing a MoU with private industrial houses without any transparency of international bidding. Environmental activist Biswajit Mohanty moved the High Court with a PIL in April 2011. Mohanty said the government decision was arbitrary and lacked transparency. The HC after hearing the PIL ordered interim stay on government signing MoUs and concessional agreements with port developers till further orders. Subsequently, when the government wanted to allow a private industrial house to construct a port at Chudamani in Bhadrak district, this was rejected by the Odisha High Court, considering that the government's whole policy on port development is currently under judicial scrutiny[148].

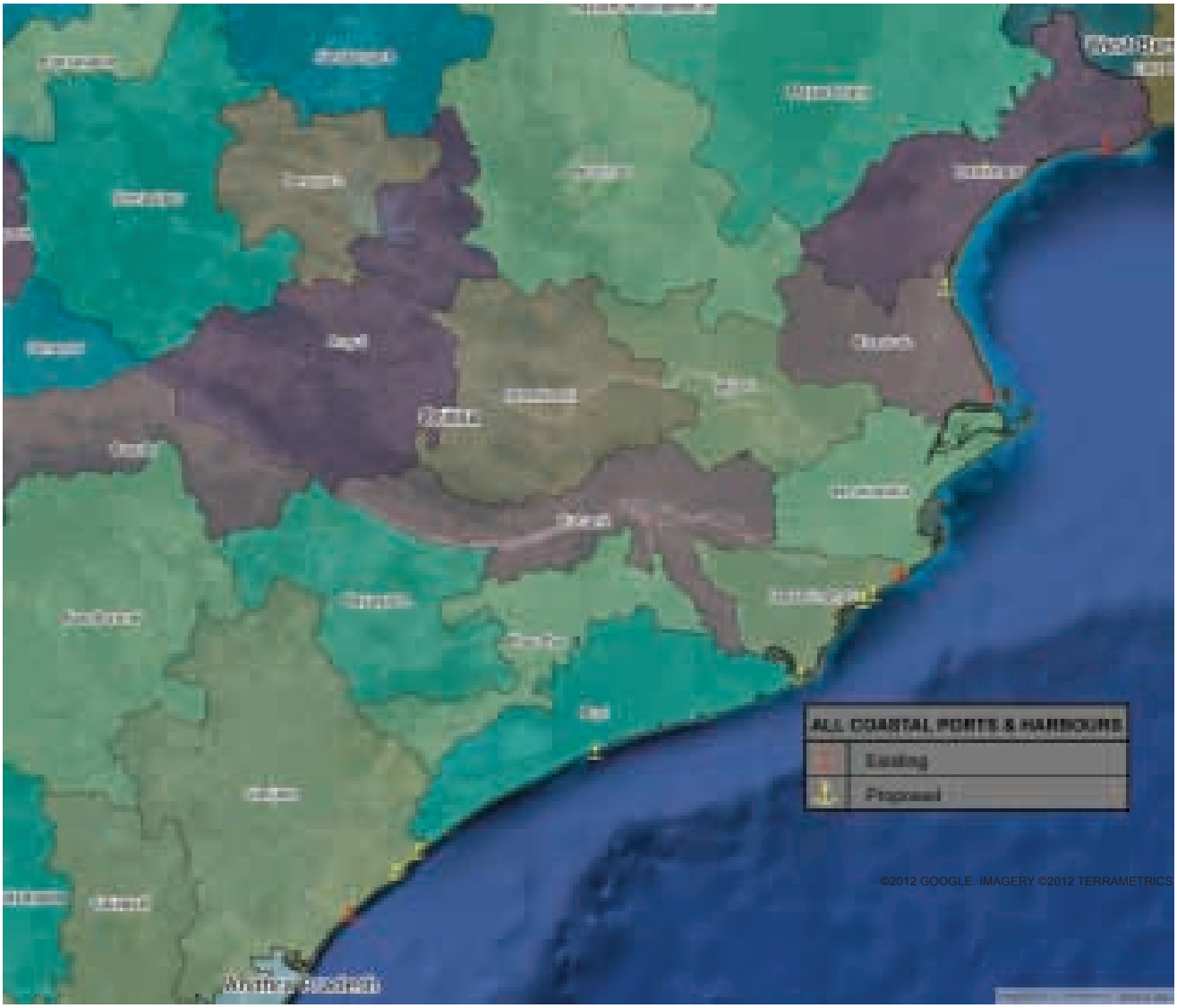


Figure 9.10.6: Ports

This project mapped the area occupied by each existing port in the littoral zone, and the information is presented in the table below.

146 Commerce and Transport Department, Government of Odisha, Port Scenario in Odisha.

147 Dash, Bishnu. Odisha to notify Talsara as 14th port site. Business Standard. Bhubaneswar 6 Nov 2009, http://www.business-standard.com/india/news/Odisha-to-notify-talsara-as-14th-port-site/21/29/375446/

148 http://articles.timesofindia.indiatimes.com/2012-05-15/bhubaneswar/31710719_1_chudamani-dhamra-mous

Table 9.10.10: Ports surveyed in this study

Ports & Harbours of Odisha							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
Baleshwar	1	0.1	-	0.1	-	0.1	-
Bhadrak	-	-	-	-	-	-	-
Ganjam	2	0.5	-	0.8	0.1	1.0	0.1
Jagatsinghpur	1	0.6	0.2	1.0	0.6	1.3	0.8
Kendrapara	-	-	-	-	-	-	-
Khordha	-	-	-	-	-	-	-
Puri	-	-	-	-	-	-	-
Grand Total	**4**	**1.1**	**0.2**	**0.2**	**0.1**	**0.2**	**0.1**

A study on groynes north and south of a jetty of Gopalpur port, that was undertaken to understand the impact of the groynes on the shoreline prior to the development of breakwaters and a groyne field for Gopalpur, showed the impact of groynes on erosion and deposition on the north and south beaches of the port. Volume, beach width, and beach area estimates indicated that the rate of deposition on the south beach was much faster than the rate of erosion on the north[149].

Table 9.10.11: Proposed ports

Proposed ports		
No. of ports		
State	**District**	**Total**
Odisha		
	Baleshwar	1
	Bhadrakh	1
	Ganjam	2
	Jagatsinghpur	3
	Puri	2
Total		**9**

Thermal power plants: Odisha Power Generation Corporation Limited (OPGC) was incorporated on 14 November 1984. OPGC started as a wholly owned Government Company of the State of Odisha with the main objective of establishing, operating and maintaining large thermal power generating stations. Currently the installed capacity is 880 MW for the state sector plants and 1,663.148 for the captive power plants. The state government has signed 13 MoUs for setting up thermal power plants in the state[150], though most don't fall in any of the coastal districts. In another listing of upcoming power plants, two, namely a 135 MW plant at Balgopalpur as part of Baleshwar Alloys Ltd and a 7.5 MW plant at Kuruda in Baleshwar district as part of Birla Tyres, would be located near the coast[151]. In this study, two thermal power plants in Bhadrak district were identified to be more than 10 kilometres away from the coast.

Special Economic Zones: In 2010, the Odisha government drew up a plan to come out with a state specific Special Economic Zone (SEZ) Policy. Under the proposed SEZ Policy, the state government was not to encourage SEZs based on mining of minerals like iron ore, chrome ore or bauxite. However, SEZs based on the use of intermediate products like alumina for smelting, primary metals for further processing on the value chain,

149 Mohanty, P.K.; S.K. Patra; S. Bramha; B. Seth; U. Pradhan; B. Behera; P. Mishra, and U.S. Panda, 2012. Impact of groins on beach morphology: a case study near Gopalpur Port, east coast of India. Journal of Coastal Research: Volume 28, Issue 1: pp. 132 – 142. doi: http://dx.doi.org/10.2112/JCOASTRES-D-10-00045.1.

150 Team Odisha. http://www.teamOdisha.org/mou_power.asp accessed 3 September 2012.

151 List of upcoming and new thermal power plants in Odisha. http://thermalpower.industry-focus.net/Odisha-power-plants.html accessed 3 September 2012.

and rare minerals like tin, limenite, nickel, platinum and vanadium would be allowed. The Odisha State Pollution Control Board was to prepare a list of such industries and the same would be notified by the state government as a negative list. Till September 2010, four SEZs had been notified in the state – the sector specific IT/ITes SEZ at Chandaka Industrial Estate in Bhubaneswar developed by Idco; sector specific SEZ for stainless steel and ancillary downstream industries at the Kalinga Nagar Industrial Complex being developed by JSL; aluminium and aluminium products SEZ at Lapanga near Sambalpur being developed by Hindalco Industries; and another aluminium SEZ with captive power plant being developed by Vedanta Aluminium Limited at Jharsuguda[152]. Recently, unable to proceed with their projects for various reasons, Vedanta Aluminium and Posco have sought more time from the Centre to implement their respective Special Economic Zones (SEZs). Posco's project delays were due to land issues: the SEZ was to come up on 1,620 ha whereas the state government had leased only 245 ha, while that for Vedanta was to do with their captive power plant[153].

Challenges/issues in the coastal zone: Recently the number of companies who have signed Memoranda of Understanding (MoUs) to set up steel plants in the state has gone up to 50, including POSCO of South Korea which has agreed to construct a mammoth $12-billion steel plant near Paradip port, named POSCO India. It would be the largest single investment in India's history[154]. Thus development appears to be on a fast track. However, there are problems, especially with the EIA for projects as well as land acquisition issues. An analysis of the EIA of the captive jetty for POSCO's steel plant showed that nothing was said about the importance of a nearby river (Jatadhari) whose mouth is a known fish breeding site, which is where the port is going to come up and would lead to closure of the river mouth. Nor was there mention of alteration in site topography due to construction, waterlogging in surrounding areas as the river already silts up easily and is maintained by traditional dredging methods by locals, or the existing betel cultivation on sweet sandy soil, etc.[155]. Similarly, the Dhamra Port was under extensive criticism for the way in which poor environmental compliance mechanisms enable corporates to easily break regulations[156].

The practice of conservation in Odisha has also had negative repercussions on the traditional marine fishers. The designation of protected areas – a well-meaning move – has resulted in traditional fishers living up the creeks not being able to access their traditional fishing grounds, as this would require their passing through the protected areas. A study concluded that it was imperative to view the fishing community as a part of the marine space and involve them in turtle conservation[157]. It has actually succeeded in many places, as in Rushkukiya. It is not as if the turtle population is at threat only from people. Apart from getting entangled in fishing gear (for which now Turtle Excluder Devices are used), pollution of the water (industries, aquaculture, sewage) as well as debris on the beach are problems to be faced. In addition, two major companies of India – Oil and Natural Gas Cooperation of India (ONGC) and Reliance Industries (RIL) – have been given permission to carry out offshore drilling off the coast of Odisha. Changes in land use pattern along the coast, dredging, erosion and loss of beaches are also important issues[158].

152 Odisha govt plans a new state-specific SEZ policy, Forum4finance. 19 September 2010. http://www.forum4finance.com/2010/09/19/Odisha-govt-plans-a-new-state-specific-sez-policy/?utm_source=feedburner&utm_medium=email&utm_campaign=Feed%3A+Forum4finance+%28Forum4Finance%29&utm_content=Google+International accessed 3 September 2012.

153 Posco, Vedanta seeks more time for SEZ projects in Odisha. The Economic Times. 11 March 012. http://articles.economictimes.indiatimes.com/2012-03-11/news/31145331_1_sez-developers-navi-mumbai-sez-approval Accessed 3 September 2012.

154 Odisha. http://en.wikipedia.org/wiki/Odisha accessed 2 September 2012.

155 Mumtaz, Rifaz. Technical Evaluation of the EIA for the Captive Minor Port of POSCO – India Private Limited, Bhubaneswar, located at Jatadharmohan Creek near Paradeep in State of Odisha. CSE, New Delhi. 2010?

156 Rodriquez, S. A. Sridhar. Dhamra Port: how environmental regulatory failure fuels corporate irreverence. Indian Ocean Turtle Newsletter No. 8, September 2008.

157 Sridhar, Aarthi. Seaturtle conservation and fisheries in Orisssa, India. Samudra Monograph. ICSF, 2005.

158 Sea turtles of Odisha – a retrospective study. Envis newsletter, Centre for Environmental Studies (CES). Vol 20, Jan-Mar 2012. http://www.cesOdisha.org/PDF/Newsletter20.pdf

9.11. West Bengal

Introduction: The fourth most populous state in India, West Bengal spreads over 88,752 km^2. The length of coastline surveyed is about 390 km. This is detailed in the district-wise breakup of coastal lengths provided in table 9.11.1. In some of the districts, there are significant differences between the lengths of coastline measured during our survey and those recorded by NATMO. A considerable variation is to be expected when measuring lengths of coastlines that are non-linear and irregularly shaped, when different scales are used for making the measuring. Along linear and regularly shaped alignments of the coastline, the differences are likely to be less.

Table 9.11.1: Length of coastline

Length of Coastline - Andra Pradesh		
Districts	Length (Surveyed)	Length (Natmo)
East Godavari	169.0	197.0
Guntur	69.9	57.0
Krishna	108.0	128.0
Nellore	169.0	163.0
Prakasam	119.0	117.0
Srikakulam	163.0	158.0
Vishakhapatnam	127.0	127.0
Vizianagaram	30.8	29.0
West Godavari	59.8	11.0
Grand Total	**1015.5**	**987.0**

According to another study[159] the coast has a length of about 160 km of which 51% consists of mudflats and 49% is marshy. Midnapore coast is characterized by sand dunes. The Sunderbans in the South-24 Parganas have an intricate coastline, clusters of deltas with interlinked channels, creeks, and estuaries. Deltaic regions are mostly clayey due to high deposit of sediments (8 million tonnes/year) through the Hooghly system.

Ecology and biodiversity: Bengal is synonymous with the Sunderbans, the largest stand of hablophytic mangroves in the world, located partly in West Bengal and partly in neighbouring Bangladesh. The Ganga-Brahmaputra-Meghna delta lies partly in West Bengal. The coastline is crisscrossed with rivers and water bodies and there are many newly emerging islands called chars located within the area. Coastal wetlands within the 500m zone were mapped in the study and are given in the table.

Table 9.11.2: List of wetlands[160]

Wetlands of West Bengal							
Districts	Mangroves	Creeks	Lagoons	Sand/Beach	Coral reefs	Salt Marsh	Mudflats
East Midnapore	5	-	-	12	-	-	1
South 24 Parganas	310	-	-	39	-	-	16
		-	-		-	-	
Grand Total	**315**	**-**	**-**	**51**	**-**	**-**	**17**

159 Integrated Coastal Zone Management Project, West Bengal. http://www.ieswm.org/pdf/State_Project_Report_2010_Summary.pdf

160 MoEF National Wetland Inventory and Assessment (NWIA). http://envfor.nic.in/division/national-wetland-inventory-and-assessment-nwia

Table 9.11.3: Marine Protected Areas surveyed in this study

Marine Protected Areas of West Bengal							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North 24 Parganas	1	41	20.5	44.0	44.0	105.1	105.1
PurbaMedinipur	-	-	-	-	-	-	-
South 24 Parganas	2	179	89.5	97.8	97.8	365.3	365.3
Grand Total	**3**	**220**	**110.0**	**56.7**	**56.7**	**121.6**	**121.6**

Many parts of the Sunderbans have come under various forms of protection, and because of the high population density in this area the CRZ notification permits the construction of amenities for the local communities even in the CRZ.

Table 9.11.4: Water bodies surveyed in this study

Water Bodies of West Bengal								
Districts	Nos. Tanks	Nos. River Mouths	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North 24 Parganas	3	-	0.3	-	0.3	-	0.6	0.1
South 24 Parganas	8	2	19.6	23.8	10.7	26.0	40.1	97.0
PurbaMedinipur	5	4	6.8	5.0	6.0	9.0	7.3	10.8
Grand Total	**16**	**6**	**26.6**	**28.8**	**6.9**	**14.8**	**14.7**	**31.8**

Coastal settlements: The space occupied by communities in the 500 m zone has been mapped in this study and summarized in the table below. In addition to the coastal settlements, commercial spaces within 500 m from the shoreline were also mapped. The high values in East Midnapore (PurbaMedinipur) are not surprising since Digha beach, a tourist attraction, is located in that district.

Table 9.11.5: Settlements surveyed in this study

Settlements of West Bengal							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
South 24 Parganas	31	52.0	23.7	28.4	26.0	106.0	96.9
North 24 Parganas	-	-	-	-	-	-	-
PurbaMedinipur	25	57.4	15.6	51.2	27.9	61.7	33.6
Grand Total	**56**	**109.3**	**39.4**	**28.2**	**20.3**	**60.4**	**43.5**

Table 9.11.6: District-wise population of marine fishing communities (CMFRI census 2010)

State/ District	Number of fishing hamlets	Number of families	Traditional fishing families	BPL	Total population
	CMFRI CENSUS 2010				
North 24 Parganas	30	9,358	7,369	6,440	40,206
South 24 Parganas	68	40,684	28,030	26,906	197,781
Howrah	23	3,750	3,542	2,952	16,250
East Midnapore (PurbaMedinipur)	67	76,981	53,532	48,870	380,138
West Bengal	188	130,773	92,473	85,168	634,375

Fishing: The total fish production in West Bengal in 2009-10 was 1.51 million tonnes. The marine fish production for 2009-10 is not available. The summary of information about the marine fishing communities of West Bengal from the 2010 CMFRI census is given below.

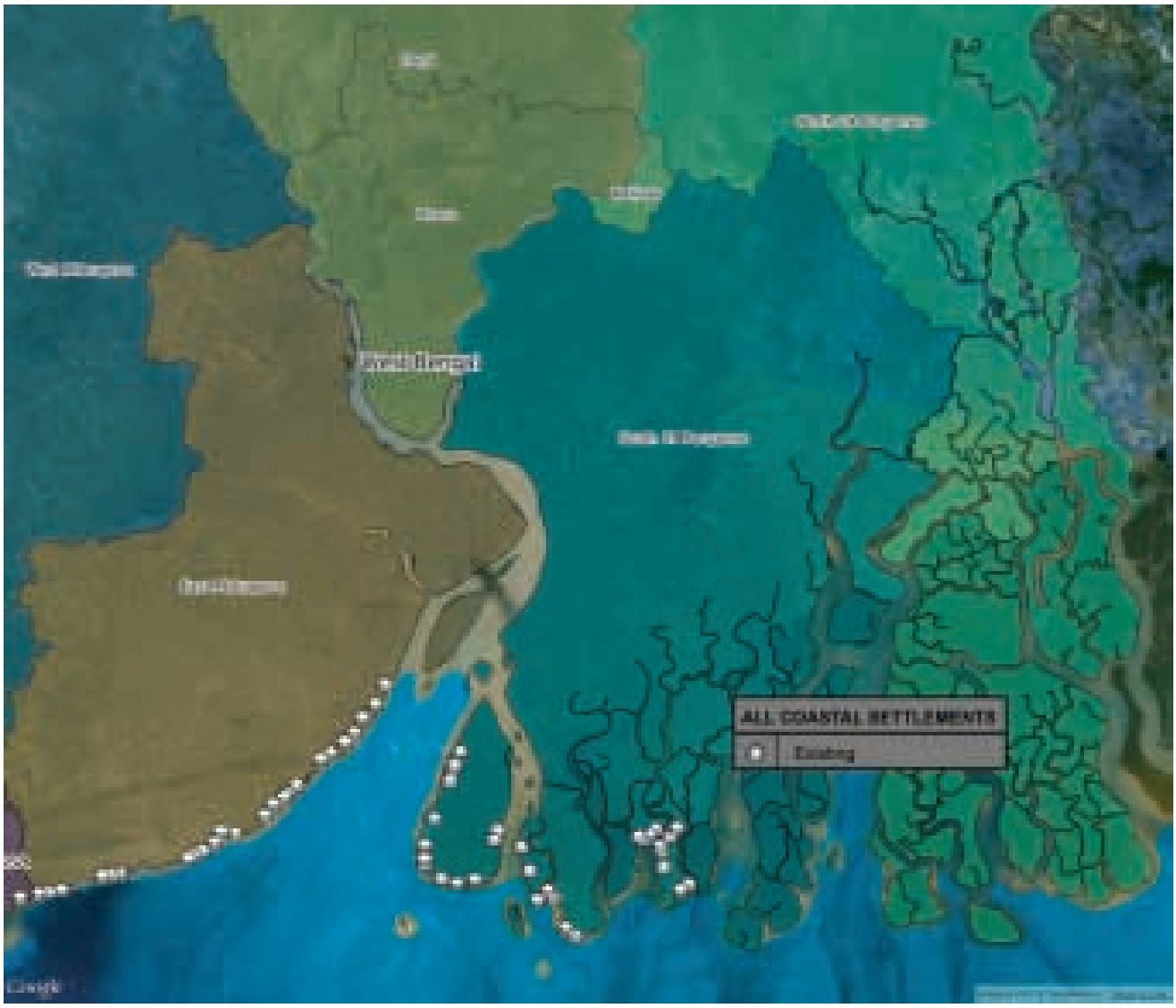


Figure 9.11.1: Settlements

Table 9.11.7: Commercial areas surveyed in this study

Commercial Areas of West Bengal							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
South 24 Parganas	86	17.7	2.0	9.7	2.2	12.5	2.9
North 24 Parganas	-	-	-	-	-	-	-
PurbaMedinipur	-	-	-	-	-	-	-
Grand Total	86	17.7	2.0	4.6	1.1	9.8	2.3

Shoreline change: According to the CPDAC, as of 2005 some 125 km of the coast was affected by erosion, of which 80 km was protected. Part of the Ganga-Brahmaputra-Meghna (GBM) delta, the state is best known for the Sunderbans, the world's largest mangrove stand, which straddles India and Bangladesh. The Sunderbans are a UNESCO World Heritage Site. Extensive portions of the Sunderbans are also under various degrees of protection. West Bengal is implementing the Integrated Coastal Management Plan project funded by the World Bank, where

the focus is to prepare plans for covering the stretches of Sunderbans, Haldia and Digha-Shankarpur in the state[161].

The coastal areas of West Bengal come under the very high damage risk zone for wind and cyclones according to the BMTPC vulnerability atlas. The 24 Parganas districts (south and north) come under the Zone IV – high damage risk zone for earthquakes, while East Medinapur comes under Zone II (moderate damage risk zone). Between the years 1891 and 2000 a total of 69 cyclones have affected West Bengal, with 24 Parganas (north and south) hit by 35 cyclones, and Medinapur 34 cyclones[162]. The latest in the series was Cyclone Aila (2009).

Coastal structures: In this project, various structures in the littoral zone have been mapped and measured and are presented in the tables below.

Table 9.11.8: Structures surveyed in this study

Structures of West Bengal									
Districts	Breakwater	Bridge	Detached breakwater	Dock	Elevated road	Jetty	Pier	Pipe line	Grand Total
North 24 Parganas	-	-	-	-	-	-	8	2	10
South 24 Parganas	-	-	-	-	-	-	-	-	-
Total Nos.	-	-	-	-	-	-	8	2	10
Total Length of Structures (km)	-	-	-	-	-	-	1.4	0.4	1.8

Figure 9.11.2: Structures

161 Integrated Coastal Zone Management Project, West Bengal. http://www.ieswm.org/pdf/State_Project_Report_2010_Summary.pdf
162 NCRMP. http://ncrmp.gov.in/ncrmp/Cyclone_Impact.html

Table 9.11.9: Seawalls & groynes surveyed in this study

Seawalls & Groynes of West Bengal						
Districts	Total Nos. Seawalls	Length Occupied (km)	(%) Length Occupied (Surveyed)	(%) Length Occupied (NATMO)	Total Nos. Groynes	Length Occupied (km)
North 24 Parganas	-	-	-	-	2	0.4
PurbaMedinipur	-	-	-	-	-	-
South 24 Parganas	14	27.2	14.9	19.2	2	0.2
Grand Total	**14**	**27.2**	**7.0**	**15.0**	**4**	**1.0**

Ports and harbours

West Bengal has two modern ports – Kolkata and Haldia – which together handled 54.22 million tonnes of cargo in 2008-09. Currently both ports are being modernized and upgraded to cope with the growth in cargo. An outlay of US$ 222.26 million has been projected in the 11th Plan for Kolkata Port Trust. The outlay for Kolkata Dock System is in the tune of US$ 45.17 million and that of Haldia Dock Complex is US$ 83.15 million. Haldia is reportedly plagued by siltation problems which are making it difficult to handle even medium size vessels, hence Haldia Dock II was to come up 7 km upstream of HDC[163]. Another proposal was to build a port on Sagar Island. The proposal dates back to 2002 and was in the process of being revived in 2010[164].

A new 3,000 acre port-cum-Special Economic Zone is coming up in Kulpi in collaboration with Dubai-based DP World. The process of setting up a deep sea port near Kolkata has been initiated by the Ministry of Shipping, Government of India. Port facilities will be spread over 1,500 hectares of land. About 1,500 hectares of additional land will be earmarked for expansion. The port is expected to have a draught of about 12 metres. A Special Economic Zone (SEZ) spread over 4,400 acres is likely to be set up around the port. BPL is also one of the promoters of the SEZ project. Recently a deep-sea fishing harbour has been approved, which will increase the export of marine fish and fish products to over 25,000 tonnes per year[165],[166]. The table below gives the area of the ports occupied as well as the width of coastline occupied.

Table 9.11.10: Ports surveyed in this study

Ports & Harbours of West Bengal							
Districts	Total Nos.	Length Occupied (km)	Area Occupied (Sq.km)	(%) Length Occupied (Surveyed)	(%) Area Occupied (Surveyed)	(%) Length Occupied (NATMO)	(%) Area Occupied (NATMO)
North 24 Parganas	-	-	-	-	-	-	-
South 24 Parganas	2	3.1	5.7	1.7	6.2	2.2	8.0
Grand Total	**2**	**3.1**	**5.7**	**1.1**	**4.1**	**1.7**	**6.3**

163 Gupta, J. Bengal to get 3rd port. The Times of India. 5 Feb. 2011.

164 New Port for West Bengal. Portstrategy. 24 March 2010.

165 WBIDC. Physical Infrastructure. http://www.wbidc.com/about_wb/physical_infrastructure.htm accessed 3 September 2012.

166 Container port in Kulpi, West Bengal. http://www.projectsmonitor.com/detailnews.asp?newsid=7852 accessed 3 September 2012.

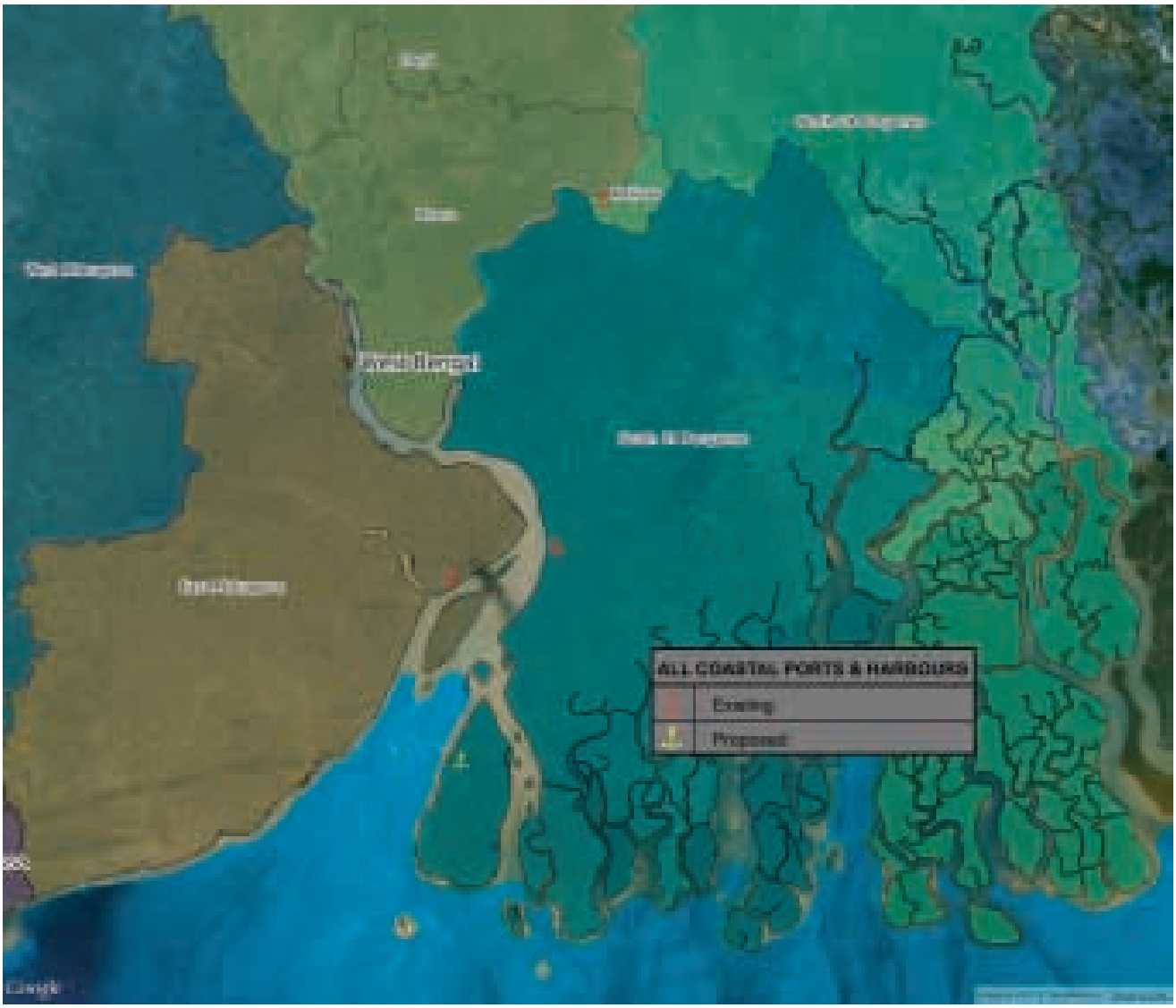


Figure 9.11.3: Ports

Thermal power plant: One coal-fired thermal power plant is proposed at Nayachar Island in East Midnapore district; however, it is located more than 10 km from the coast.

Challenges/issues in the coastal zone: The statement on the ICZMP project website[167] 'Digha-Sankarpur area's western sideways has become vulnerable to coastal erosion in some of its stretches due to unbridled and rampant human interventions' is not qualified by describing what these human interventions are, as it goes on to say that what is required is to contain 'the damages caused due to periodic storm and tidal surges, seasonal high velocity winds, storms and cyclones'. Others describe the rapid building up of hotels and resorts on the beach as a problem. Digha is a major tourist resort in West Bengal. Massive coastal erosion, to the extent of 15 to 20 metres a year, has led to loss of land and property. Digha, which has nearly 400 hotels to accommodate the great rush of tourists round the year (over 1.6 million tourists every year), has almost reached a saturation point[168]. The sand dunes of Mandarmani are a major tourist destination in this area, which were protected by traditional fishers who visit the area seasonally. The planting of screw pines stalled erosion and built up beaches. However, this area has been ravaged by allowing building right on the beach[169].

167 Containment of Coastal Erosion. http://iczmp.semaphoreindia.com/main/coastal_erosion_digha.php

168 Mondal, Amal Kumar, Sanjukta Parui, Natasha Das, Asim Mandal, Pijush Kanti Das, Tamal Chakraborty, Debashis Bhunia and Babulal Sasmal, 2010. Eroding beaches of West Bengal. Science Reporter. June 2010.

169 DISHA. 2007. Vandalizing the coast at Mandarmoni – Time to Act. https://sites.google.com/site/nffcrz/violations/west-bengal/mandarmoni

10 Observations, findings & recommendations

Perhaps the time has come to cease calling it the "environmentalist" view, as though it were a lobbying effort outside the mainstream of human activity, and to start calling it the real-world view.

E.O. Wilson

This report has explored the various benefits that we derive from the coast, the various traditional uses and users of the coast, and the current developments on the Indian coast. It has gone into some depth on problems specific to coastal structures, port development and thermal power plants. Presented here are some of the observations and key findings, as well as recommendations to protect the coast and ensure its sustainable use.

Broad Observations

What is striking in this report is the wonder that is India's coast: the beauty, the rich biodiversity, the resources, and the productive habitats that India's beautiful coastline is endowed with. There is a wide range of ecosystems such as mangroves, coral reefs, seagrass beds, mudflats and sandy shores. There is also a huge population of people who are traditionally dependent on these resources.

What is also evident is that the coast is challenged by aggressive development as a result of economic reforms and globalization; marshlands and tidal flats are 'reclaimed', creeks are diverted, and mangroves are felled to make way for ports, power plants and large industries. Subsequently the areas around them also come under development pressure – for ancillary industries, tourism projects and settlements. As more people migrate towards the coast, there is extensive change in land use and increasing pressure on resources; a natural landscape is rapidly converted to a mosaic of human activity with unprecedented strain on natural ecosystems. Physical alteration and destruction of habitats has been identified as an area for priority attention by the UNEP, and the CBD lists it as one of the major causes of loss of biodiversity.

This exploratory study shows that coastal structures, harbours, ports and thermal power plants are coming up, and in such numbers and scale that they seriously threaten the future of our coasts. Ports, harbours and other coastal structures directly modify the coastline and its habitats, and with so many new projects in the pipeline the danger that we will be left with very little of the natural and healthy coast is real.

Ironically, many of the coastal structures – groynes, seawalls, etc. – are built to protect the coast against erosion but tend to further aggravate the problem and endanger the coast.

Thermal power plants have more of an indirect impact on the coast. Pumping of seawater for cooling, release of hot water into the sea, captive jetties for fuel supply, pipelines and channels through sand dunes, mangroves, inter-tidal zones and other ecologically sensitive areas can create negative impacts on marine living resources, fisheries, livelihoods and the coastal eco-system. Nuclear power plants, which are a specific class of

thermal power plant, come with the same problems. Only, they have the additional risks (claimed to be very low) associated with nuclear fuel and radioactivity.

While this study only explored three sectors – ports & harbours, other coastal structures and thermal power plants – there is every reason to believe that the cumulative impact of the plans and proposals of all sectors (and Ministries) seeking investments on the coast can be horrendous. Even if individually many of these projects appear innocuous or as having acceptable levels of negative impact, together they can be catastrophic. The near 6,000 km coastline (of mainland India) appears to be a long one, but it is clearly not long enough for the various investments that are now being planned or proposed along it.

It is also important to recognize that a large coastal community, especially fisher-folk, is dependent on the coast and its resources, and all new investments can cause serious harm and injustice to a large number of people, forcing them to move away from traditional livelihoods and associated lifestyles and culture.

It is also a matter of grave concern that all this "development" is taking place in spite of having many laws and regulations to protect the environment in general, and the coast in particular. This clearly indicates serious lacunae in laws as well as their implementation.

Key findings (from the study of ports, other coastal structures and thermal power plants)

The most striking thing about the analysis is that human activities such as infrastructure developments and coastal structures are rapidly modifying India's coastline, and that the single biggest cause of endangerment to biodiversity loss is the degradation of the coastal habitats.

Coastal structures

Coastal structures have considerable negative impact as they:

- Destroy space for coastal processes, recreation and cultural activities
- Cause salt water ingress into ground water aquifers
- Affect livelihoods of fishing and coastal communities
- Upset sedimentary budgets and littoral drift
- Trigger down-drift erosion
- Often cause inter-state issues
- Destroy the natural beauty of the coast.

Often failing to protect even the stretch of coast they were expected to protect, they also cause damage to the coast in the adjacent areas. This is causing considerable distress to coastal populations and leading to loss of valuable coastal lands and beaches. Properly planned and executed beach tourism can generate significant income and provide employment to the local community as well.

With nearly 30% of the coastline facing erosion, the problem of erosion is being tackled by "hard" solutions like seawalls and groynes without going into the root causes, further aggravating the problem. Though at the national level only about 8% of the Indian (mainland) coastline has seawalls, the proportion is extremely high in erosion-prone states like Kerala. Further increase in the proportion of "protected" coast with seawalls and groynes is not desirable.

Quarrying of stone for construction of coastal structures in nearby areas also causes degradation of other eco-systems beyond the coast.

There is a lack of awareness among those living on the coast about the causes of coastal erosion and the possible ways to resolve them. Often it is the ordinary coastal dweller, fearful of losing his home as a result of erosion, who becomes the driving force for putting up a seawall in front of his village. At times they are aware of the root cause of the problem but are convinced that the government will do nothing to set it right.

Ports

While ports are essential for our trade and economy, their negative impacts have been largely ignored. A wide range of such impacts – shoreline changes, severe erosion, loss of valuable beaches, destruction of valuable eco-systems, displacement of fishing communities, etc – have been documented by this study, indicating that port development has to be a judiciously planned affair. The main reason that ports have caused such alarming damage is because the needed mitigation measures have not been carried out; they have remained only on paper .

With 181 minor ports and 12 major ports, the port density or frequency on the Indian mainland varies depending on the coastline length one chooses from various sources of information; there is one port every 28 to 31 km. Given that each port can have an impact on a fairly long stretch of coastline on either side, the port density is already very high. With 76 new ports being proposed in addition to the large numbers already dotting the coastline, the threat to the Indian coastline is serious and needs immediate attention.

With low capacity utilization and considerable land available in existing ports to further expand capacity, there is an opportunity to rationalize port development without increasing port density and negatively impacting the environment. The policy that favours development of private ports by allowing them lower tariffs compared with those of the major (state-owned) ports should be reworked as well.

The proliferation of ports raises another very serious issue: knowing well that the coast is highly dynamic morphologically and ecologically, and that the breakwaters trigger erosion which is on-going and often irreversible, who will carry out the mitigation measures which will have to continue for ever in case the ports go bankrupt due to competition or economic slowdown?

Power plants

Power plants on the coast, even if the plant itself is beyond the CRZ, depend heavily on pumping water from the sea for cooling and pumping back hot water into the sea. This often involves the cutting of channels through valuable beach, mangrove or sand dune ecosystems and through precious inter-tidal areas (as in Kachchh). In addition, many power plants tend to seek construction of their own jetties and coastal structures to have captive facilities for coal imports. The environmental losses – coastal and marine – are considerably underestimated as are losses in livelihoods and displacement of fishing and other coastal communities.

At present there are 27 power plants on the coast with an installed capacity of 19,300 MW. Another 59 plants with a capacity of 92,000 MW are proposed along the coast, more than double the number of plants on the coast and increasing the capacity more than four times. With the current weaknesses in technology choice and environmental impact assessments, this expansion can cause great harm to our coastal and marine eco-systems' biodiversity. Since many of these proposed plants are bunched together in certain areas like, for example, the Konkan region on the west coast and Nagapattinam district on the east coast, the cumulative impact can be very significant and destroy coastal biodiversity as well as livelihoods.

These ports and power plants not only have an impact on the coast but also on the coastal wetlands which affect communities and ecosystems i.e. a broad range of species dependent on them and the ground water table. As a result there is also a serious threat to our water and food security.

NCPC findings from consultations

NCPC, a broad based network of NGOs, fish-worker organizations and individuals keen to protect the coastal eco-systems and livelihoods, and working on reforms and effective implementation of laws and regulation governing the coast, held numerous consultations with civil society groups and communities directly impacted by development to get an in-depth understanding of the various factors contributing to degradation of India's coast. Based on these consultations and the above findings of the report it is evident that there is an urgent need to review our development plans and bring them in line with the carrying capacity of the coast and India's commitment to protect important coastal ecosystems and bio-diversity, as enshrined in various international conventions and agreements.

Lacunae at systemic level

Much of the above problems at sector level (ports, coastal structures and power plants) can be traced to bigger systemic problems in coastal governance and even environmental governance as a whole. The following lacunae at the level of overall coastal governance has been noted by the National Coastal Protection Campaign (NCPC) in the course of its various efforts to fight for the coast and various studies done by its members.

Given that the various problems related to coastal projects can be attributed to lacunae in planning, impact assessments, laws, sanctioning process and enforcement, the NCPC observations are classified accordingly.

Planning

The current system of planning by individual line Ministries is deplorable in addressing environmental issues; each Ministry has its own tunnel vision, as there is no comprehensive information available about all the other projects, and therefore ignores the cumulative impact of its plans on the environment.

Each Ministry makes its own plans without understanding or bothering about the plans of the other Ministries for the coastal area. This absence of a "national perspective", which takes into account the carrying capacity of the coast, is visible at all levels and contributes to the current chaos on the coast.

The same lack of coherence exists between Central and State Government plans, with many states pushing ambitious plans for projects on the coast using private funding.

Impact Assessments

The Environmental Impact Assessments (EIAs) are done on the basis of weak Terms of Reference (ToRs). The marine and coastal ToRs are currently weak and do not reflect the range or seriousness of the impacts.

The EIAs are mainly single project oriented and completely ignore the cumulative impacts that arise from the projects themselves, namely the other developments that are triggered by the project. They also ignore the cumulative effects of the project when taken together with other (both similar and other) projects in the vicinity.

The EIAs by private consultants commissioned by project proponents tend to understate environmental impacts as well as social and economic impacts on local communities. They are often "made to order". The public consultations are often an eye-wash and manipulated.

Local communities do not have access to all relevant information to assess the impact a project will have on their livelihoods and local environment. Civil society is systematically denied access to information about the project, and the information lies scattered between Ministries and between Central and State Governments, aggravating the problem.

The research on the impact of projects on the coast on coastal and marine ecosystems is weak and not able to provide adequate feedback to properly assess new projects.

Laws and regulations

The CRZ 2011, despite many good provisions, is still a hotch-potch retaining many of the liberal exemptions that crept into CRZ 1991 through a series of amendments. Many of these exemptions defy logic and cannot stand the scrutiny of environmental protection.

The low status of CRZ as a mere notification under the Environment Protection Act (EPA), that can be amended at will by the Executive, makes it a weak instrument for coastal regulations.

The non-recognition of cumulative impact of projects remains a major lacuna in the CRZ.

The actual system of governance of the environment remains weakly sketched in the existing environmental laws and contributes to the current state of the environment in no small measure.

There is no accountability to make the project proponents or the sanctioning and enforcement agencies culpable for failing to discharge their duties and commitments in protecting the environment.

Sanctioning process

The committees to sanction projects on the coast do not take decisions with the necessary rigour and allow so-called "national interest" to sway their decisions without strict application of mind and the environmental laws and criteria.

The composition of the committees is predominantly Government employees who can be pressurised to support the projects of the Ministries; civil society participation with genuinely independent environmentalists and

experts is weak or even non-existent on many of the committees; coastal communities are rarely represented on any of the committees.

Full information is rarely available to the committees, and with field verification being rare, many potential problems with the project go unnoticed. It entirely depends on the "file" built by the concerned officials and the project proponents.

The strong nexus between politicians and project proponents (especially at state level) vitiates the atmosphere and makes genuinely independent decision making very difficult.

Projects continue to get approved with flawless DPRs and EIAs on paper by the sanctioning authority even though many of them do not have prior experience in the field and most of the existing ports and power plants have not kept their commitment to protect the environment.

Enforcement

There is virtually no monitoring and enforcement machinery at Central Government level, and the State machinery is weak or compromised.

Project proponents tend to start activities without appropriate permissions and then try to get them ratified through the sanction process, sometimes pointing at the enormous investments that have already been made; the string of conditions attached to the project sanction document can be violated at will due to lack of monitoring and enforcement. While there are requirements for compliance, no one appears to know about them, or to follow up on them.

Post project monitoring of environmental aspects (e.g. air pollution, marine pollution, water extraction, etc.) is so weak that even projects that blatantly violate all norms continue to function without any challenge. The CRZ remains one of the most violated regulations. Most regulators i.e. officials of coastal zone management authority, lack training and understanding of the environmental and social aspects of the coast.

No regular environmental impact assessments are carried out to determine the actual social and environmental impacts of the project.

Public involvement in monitoring and enforcement is weak, as it is not encouraged, and there is lack of information and knowledge to take on the system.

NCPC recommendations on system reform

Based on the above observations on the coast, home to a wealth of natural resources, and the pace at which it is being destroyed due to systemic problems, the following recommendations should be considered if India is serious about protecting its natural assets and the livelihoods of coastal communities. The Ministry of Environment and Forests (MoEF), with a view to making coastal governance transparent and accountable, should:

1. ***Policy:*** Draft a coastal policy, considering the length of India's coastline, for conservation of biodiversity and ecosystems in the planning stage and not at individual project level to safeguard the rich natural resources of the country.
2. ***Planning:*** An overall, integrated planning should be the basis of all decision making. Starting with the international and national goals and commitments on the one hand and going down to the regional on the other (keeping bio-regions in mind), this planning should be based on comprehensive information, carrying capacity, cumulative impacts and precautionary principles. Environmental and social concerns must be the guiding principles of all planning. Not only the states but also the major stakeholders must be part of the planning process so that poorly planned developments undertaken presently, even with all statutory clearances, are not regretted later, turning out to be wasteful, destructive and unsustainable. MoEF must insist that statutory clearances are applied for before the start of projects and not after work has already commenced, as has often happened.
3. ***Coordination:*** Play a proactive role in implementing the Environment (Protection) Act by establishing an inter-ministerial coordination committee during the planning process, both at the Central and State levels, and making environmental aspects form the base layer of any planning exercise.

4. ***Capacity building:*** Strengthen environmental governance with adequate human and financial resources for monitoring and enforcement in keeping with the number of projects sanctioned, as currently there is insufficient capacity and accountability of those dealing with governance of the coast.
5. ***Civil society participation:*** Engage the local community in the decision making process at the inception stage of the project to make development inclusive and harmonious.

   Include independent specialists known for their integrity from civil society and representation from fishing communities at all levels in the CRZ and infrastructural committees to explain the ground realities.
6. ***Assessment of damage:*** Conduct at the earliest a detailed assessment of existing projects, which takes into account environmental, social and economic impacts, cumulative impacts and habitat loss, mitigation costs and current efficiency, with possibilities for upgradation.
7. ***Environmental Impact Assessments:*** (a) Review the EIA process for coastal projects to improve the Terms of Reference for marine and coastal EIAs. (b) Make the EIAs independent of project proponent and commissioned by MoEF. While the current requirement of the MoEF towards insisting on NABET (National Accreditation Board for Education & Training) certification of EIA consultants is a step in the right direction in improving quality of EIA, the team evaluating the final EIA needs to be knowledgeable and unbiased.
8. ***CRZ 2011:*** (a) To remove from CRZ 2011 the various exemptions that go against the principles of CRZ, and add provisions which are already enshrined in the EIA 2006 but not being implemented, to stress on cumulative impacts, carrying capacity and precautionary principles. Tools for some of these, currently weak, must be strengthened. (b) Elevate the CRZ notification to the status of a subordinate legislation under the EPA. (c) To implement the provisions of CRZ 2011 that seek strict action on past violations of CRZ 1991 and stoppage of all untreated effluents being dumped in the sea.
9. ***Information dissemination:*** To make available in the public domain and on a single platform, in a digitized format, all the relevant and comprehensive information on projects, including detailed maps, for better public involvement and assessment of projects.

Recommendations (specific to sectors studied)

While the above recommendations relate to the larger reform of the system that deals with coastal projects, there is an urgent need to address the challenges faced presently on account of the specific sectors mapped in this project. The Ministry of Environment and Forests, with a view to stop further destruction of the coastal ecosystems, biodiversity and the livelihoods of indigenous coastal communities, and to ensure the future sustainability of the coast, should see to the following:

1. ***Ports:*** Stop all sanctions for new ports and expansion of existing ports until an assessment is made to determine the demands from all other sectors needing the shorefront, the carrying capacity of India's coastline, and the actual requirement of number of ports, and afterwards ensure that the existing ports carry out the mitigation measures as mandated.
2. ***Power plants:*** Declare a moratorium on all new power plants – including those sanctioned and yet to start off – until a comprehensive study is made of the impact of power plants on the coast and marine eco-system and it is possible to develop a proper policy on the construction of power plants on the coast.
3. ***Coastal structures:*** Strictly implement CRZ 2011, which requires EIA for all coastal structures, including seawalls and groynes, and make it mandatory to take into account the cumulative impacts at sediment cell level.
4. ***Transparency:*** Institutionalize a mechanism to involve all the stake holders i.e. Central and State governments, institutions, civil society, funding agencies and media for effective planning, implementation and monitoring of projects to ensure inclusive development.
5. ***Accountability:*** (a) Penalize project proponents for past violations and causing environmental destruction, and institutions for failing to discharge their duties in protecting the environment, on the lines of "polluter pays" principle. (b) Incorporate liability clauses in all future contracts and set up a liability fund as a security against collateral damage.

6. ***Restoration:*** Initiate a programme to restore affected coastlines, with suitable funding mechanisms.
7. ***Erosion*****:** Prepare a national plan and strategy to handle erosion, which looks into alternative technologies, greater investments and institutional arrangements between current agencies involved in coastal protection, rather than attempt to respond locally with seawalls or groynes as emergency measures.
8. ***Awareness creation:*** Conduct an awareness programme across the coast and among relevant agencies and communities about the wealth and value of the coast, the challenges it is facing, and the laws and regulations governing it to ensure a sustainable future for generations to come.
9. ***Funds:*** Allocate specific funds for coastal protection: studies & research, awareness campaign, consultations, training and capacity building, and restoration of affected coastline.

In conclusion:

The above list may seem long and complex, but it can be achieved with a few groups and individuals generating breakthrough initiatives that impact specific themes. Information, however, is critical for all dimensions of good governance.

Very clearly, a long process of mapping the coast has been initiated. What was prepared for COP 11 was just the framework for the database, with data on a limited number of parameters. Our hope for this was that it would encourage other organizations to contribute to expand the database with a view to creating a healthy coast and flourishing ecosystems .

The coast is a national asset which belongs to every citizen of India. NCPC will build collaboration with government agencies, academic institutions, other organizations and individuals to fundamentally transform the current development paradigm to one which results in happiness and well-being of all people by actively fostering dignity and justice.

Glossary

Although most of these words and abbreviations are explained where they first appear in the report, they are given here to assist anyone who may have missed the original explanation by jumping directly to a later stage in the report.

Abiotic	–	non-living chemical and physical factors in the environment which affect ecosystems.
Aeolian	–	processes, in the study of geology and weather, that pertain to wind activity and its ability to shape the surface of the Earth.
Anthropogenic	–	human impact on an environment.
BNHS	–	Bombay Natural History Society
CAMP	–	Coastal Area Management Programme (or Project)
CBD	–	Convention on Biological Diversity
CCA	–	Carrying Capacity Assessment
CMFRI	–	Central Marine Fisheries Research Institute
COP	–	Conference of the Parties
CPCB	–	Central Pollution Control Board
CPDAC	–	Coastal Protection & Development Advisory Committee
CRZ	–	Coastal Regulation Zone
CRZN	–	Coastal Regulation Zone Notification
CZMP	–	Coastal Zone Management Plan
Deltaic	–	Pertaining to deltas seen at river mouths where they enter the sea
EIA	–	Environmental Impact Assessment
EMP	–	Environmental Management Plan
EPA	–	Environment Protection Act
Faunal	–	to do with animals cf. floral, which is to do with plants
GEO	–	Group on Earth Observations (an intergovernmental organization leading a worldwide effort to build a Global Earth Observation System of Systems (GEOSS)). GEO is also sometimes used to refer to Global Environment Outlook.
Geomorphology	–	Scientific study of landforms and the processes that shape them.
Geotubes	–	Sediment-filled sleeves of geotextile fabric usually having an oval cross-section of around 12 ft.
GPA-LBA	–	Global Programme of Action – Land Based Activities
Groyne (USA groin)	–	a rigid structure built out from a seashore or river bank that interrupts water flow and the movement of sediment

HTL	–	High Tide Line
ICZM	–	Integrated Coastal Zone Management
INFC	–	Indian NGO Forum for CBD
IPCC	–	Intergovernmental Panel on Climate Change
IUCN	–	International Union for Conservation of Nature
Littoral zone	–	the part of a sea, lake or river that is close to the shore
Longshore drift	–	the transportation of sediments (clay, silt and sand) along a coast at an angle to the shoreline
MEA	–	Millennium Ecosystem Assessment
MEF	–	Ministry of Environment & Forests
MES	–	Ministry of Earth Sciences
MoEF	–	Ministry of Environment & Forests
MoES	–	Ministry of Earth Sciences
MOP	–	Meeting of the Parties
Morphology	–	Study of form and structure
MoU	–	Memorandum of Understanding
NABET	–	National Accreditation Board for Education & Training
NATMO	–	National Atlas & Thematic Mapping Organisation
NCPC	–	National Coastal Protection Campaign
NDSAP	–	National Data Sharing & Accessibilty Policy
Neritic zone	–	the coastal waters extending from the low tide mark to the edge of the continental shelf, with a relatively shallow depth extending to about 200 m.
NFF	–	National Fishworkers Forum
NGO	–	Non-Governmental Organisation
NHO	–	National Hydrographic Office
NIO	–	National Institute of Oceanography
NMDP	–	National Maritime Development Programme
NMPA	–	Notified Marine Protected Area
OSPAR	–	Convention for protection of the marine environment of the north-east Atlantic
PCPIR	–	Petroleum Chemicals and Petrochemicals Investment Region
PondyCAN	–	Pondy Citizens' Action Network
RCC	–	Reinforced cement concrete
SAC	–	Space Application Centre
SAV	–	Submerged Aquatic Vegetation
SEZ	–	Special Economic Zone
SICOM	–	Society for Integrated Coastal Management
SIFFS	–	South Indian Federation of Fishermen Societies
SIR	–	Special Investment Region
SOI	–	Survey of India
TISS	–	Tata Institute of Social Sciences
ToR	–	Terms of Reference
UNEP	–	United Nations Environment Programme
Vivipary	–	In plants, reproduction via embryos, such as buds, that develop from the outset without interruption, as opposed to germinating externally from a seed.

All Annexures (I, II & III)

To save paper and for easy handling and use of the information contained in Annexure-I, II & III, we have preferred to provide soft, digital copies of the content.

The content in digital format can be downloaded from:

www.thechallangedcoastofindia.in

Tata Institute of
Social Sciences

TISS (**Tata Institute of Social Sciences),** established in 1936, was the first school of social work in India. It is an institution of excellence in higher education that continually responds to the changing social realities through the development and application of knowledge, towards creating a people-centred and ecologically sustainable society that promotes and protects the dignity, equality, social justice and human rights for all, with special emphasis on marginalised and vulnerable groups.

Website: http://www.tiss.edu/

NCPC

National Coastal
protection Campaign

NCPC (National Coastal Protection Campaign) is a broad based network of NGOs, fish-worker organizations and individuals, fighting to protect the coastal eco-systems and livelihoods. It is a mix of local, national and international organisations working on reforms and effective implementation of laws and regulation governing the coast while constantly interacting with relevant Government agencies and coastal communities.

Website: http://ncpcindia.wordpress.com/

PondyCAN!
Pondy Citizens' Action Network

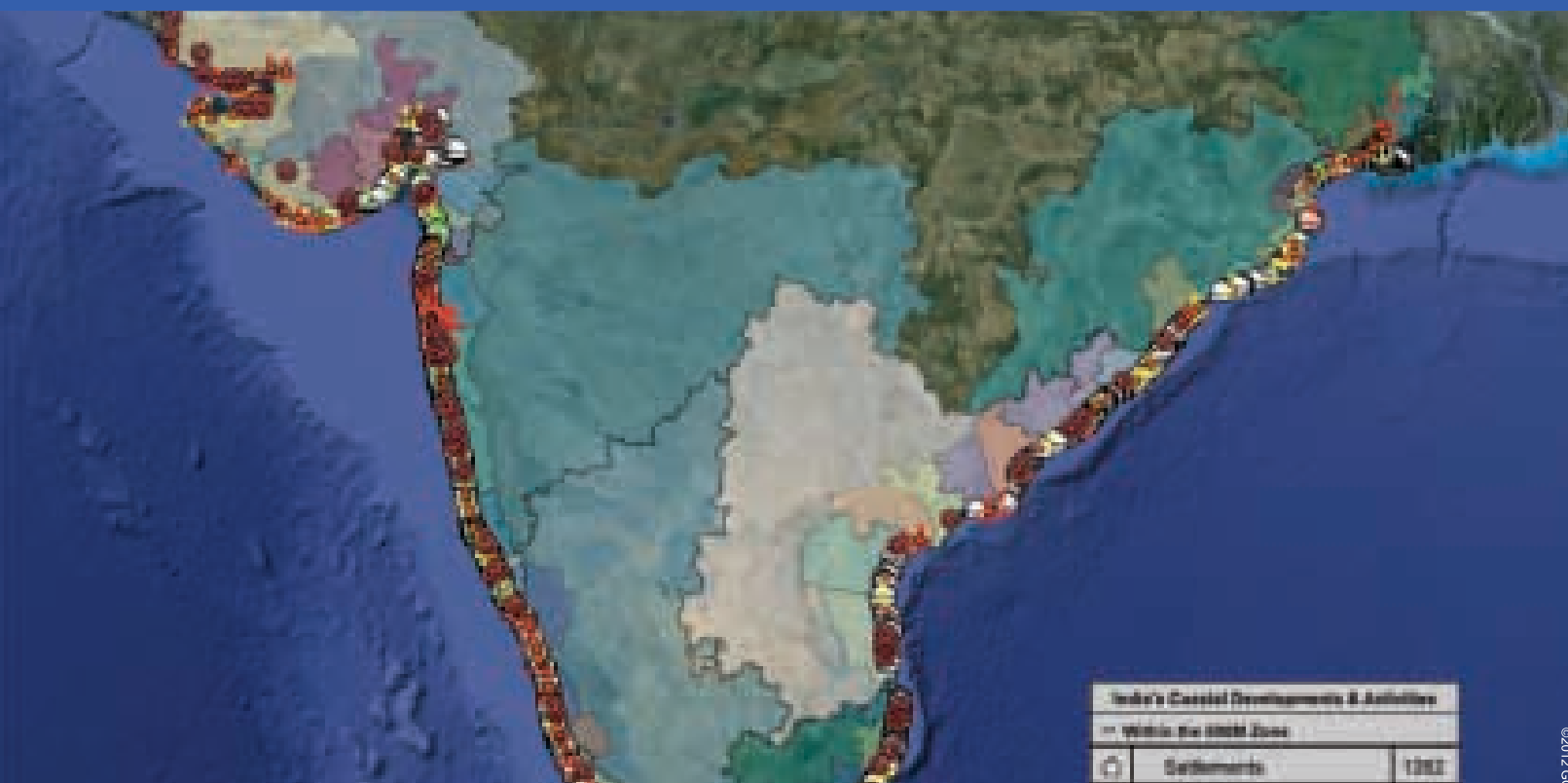
PondyCAN! (Pondy Citizens' Action Network), is a broad based, nonprofit, organization committed to work for an integrated, inclusive and holistic development which has as its focus the happiness and well-being of the people; harmonising economic prosperity with the natural, cultural and spiritual heritage. It endeavours to foster social innovation and transformation by facilitating a dynamic collaboration between the government and civil society to strengthen good governance. Restoration of the eroded Pondicherry coast is one of its key areas of work.

Website: http://pondycan.org **Email:** pondycan@pondycan.org

BNHS (Bombay Natural History Society) Established in 1883, The Bombay Natural History Society is today the largest non-government organisation (NGO) in the Indian sub-continent engaged in nature conservation research. In the 129 years of its existence, its commitment has been, and continues to be, the conservation of India's natural wealth, protection of the environment and sustainable use of natural resources for a balanced and healthy development for future generations. The Society's guiding principle has always been that conservation must be based on scientific research - a tradition exemplified by its late president, Dr. Sálim Ali. It is designated as a Scientific and Industrial Research Organization (SIRO) by Department of Science & Technology, Government of India.

Website: http://www.bnhs.org

The Challenged Coast of India



If we are serious about conserving the coastal ecosystems and biodiversity and ensuring that the coastal communities are not displaced or affected, we need to rationalize development.

In this age of technology and reforms this report is a first step towards compiling relevant and comprehensive information at a national scale, digitizing it and making it available to all in a user friendly form so that coastal governance is transparent and accountable.

A collaboration of governments, institutions, organizations and individuals can fundamentally transform the current development paradigm to one which results in happiness and well-being of all people by actively fostering dignity and justice.

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