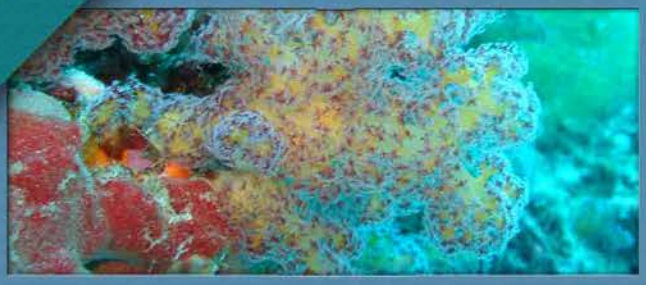
Bay of Bengal Large Marine Ecosystem Project



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National Assessment of Coastal Pollution Loading and Water Quality Criteria - Bay of Bengal Coast of India

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September 2011

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Food and Agricultural Organization

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PREFACE

The Bay of Bengal Large Marine Ecosystem has been identified as one of the world's sixty-four Large Marine Ecosystems (LMEs) sharing a distinct bathymetry, hydrography, productivity, and tropically dependent populations. The BOBLME Project involves eight countries, namely Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand with the primary goal of enhancing the livelihood security of coastal population of these countries. This is a coordinated, cross-region, program of action of all the eight countries through improved regional management of the Bay of Bengal environment and its fisheries.

The countries of the BOBLME region are some of the most densely populated (over 400 million), with large numbers living in poverty and highly dependent on coastal resources. Most of these people are poor and rely heavily on the marine resources which are being affected by overfishing, removal or degradation of important marine habitats, and pollution. Urbanization and industrialization in these countries is also proceeding at a rapid rate and has added to the pressures faced by the coastal ecosystems.

Country reports updating the current status of coastal (land based) pollution and water quality criteria in the Bay of Bengal region was initiated in April 2010. This report reviews past trends and current status of coastal pollution and recommends priority actions along the Bay of Bengal coast of India. One of the goals of this review is to enhance the current understanding of coastal and marine pollution and the various criteria prevalent to combat pollution on India's Bay of Bengal coast.

Data presented in this review is drawn from multiple published sources and has been interpreted systematically using GIS and Ocean Data View. Supporting documentation on legislations, governance and policy issues have also been consulted and synthesized for better understanding on India's efforts to combat coastal and marine pollution.

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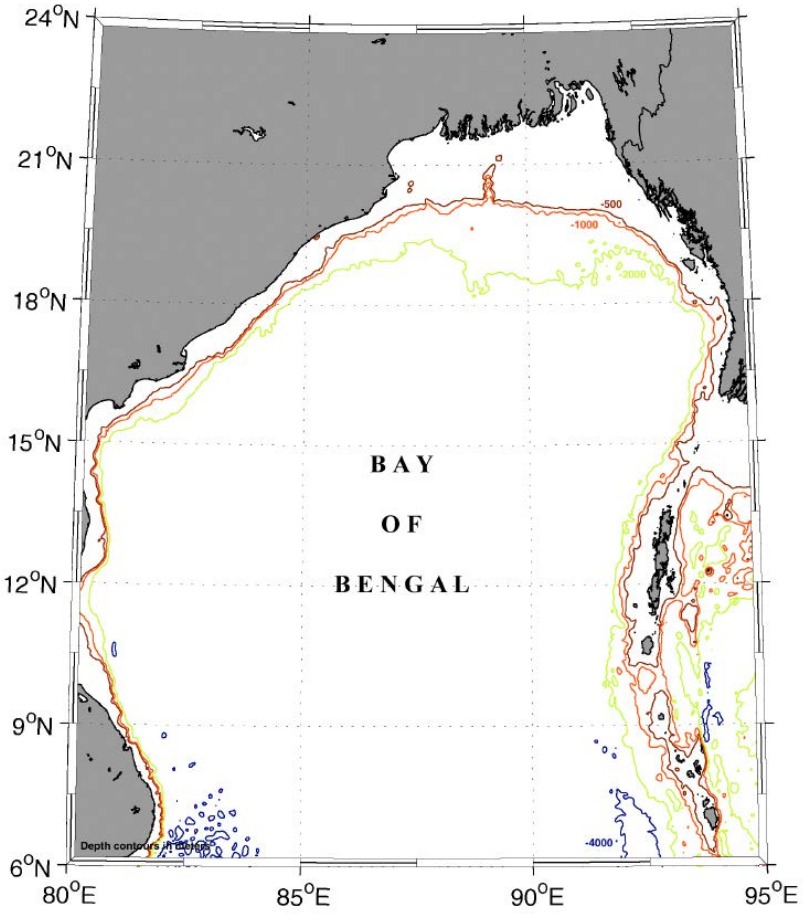
CHAPTER 1: THE BAY OF BENGAL COAST OF INDIA

1.1 Biogeographical Features

The Bay of Bengal is a large embayment of the northeastern Indian Ocean (Fig. 1.1), occupying an area of ~2,173,000 km^2, lying between latitudes 5° and 22° N and longitudes 80° and 90° E [1]. It is bordered by Sri Lanka and India to the west, Bangladesh to the north, and Myanmar (Burma) and the northern part of the Malay Peninsula to the east. According to the definition of the International Hydrographic Bureau, the southern boundary extends from Dondra Head at the southern end of Sri Lanka in the west to the northern tip of the Indonesian island of Sumatra in the east. The bay is ~1600 km wide, with an average depth of > 2600 m.

Fig. 1.1: Bathymetry of the Bay of Bengal

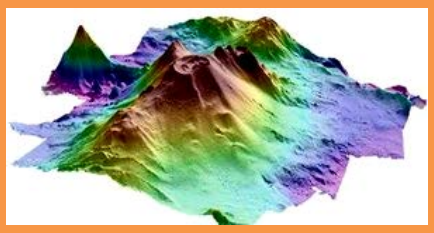


The maximum depth is 4694 m. A number of large rivers—the Mahanadi, Godavari, Krishna, and Cauvery from the east and the Ganges and Brahmaputra from the north—flow into the Bay of Bengal [2]. The Andaman and Nicobar groups, which are the only islands, separate the bay from the Andaman Sea [1]. The Bay of Bengal has a thick pile of sediments (Bengal Fan) which cover the entire basement and render the ocean floor bathymetry virtually featureless [3] (Fig. 1.1).

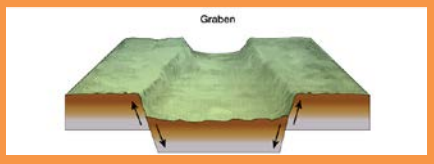
The sediment cover is exceptionally thick, ~21 km at the apex of the Bengal fan in the Bangladesh offshore region and decreases gradually to about 8 to < 2 km in the central and southern parts [4]. In the distal reaches of the fan, at 7° S, the sediments are a few hundred meters thick. Very little is known about the features associated with the oceanic basement of the Bay of Bengal.

In the northern end of the Bay of Bengal, the bathymetry is shallow, and depth to the seabed is less than 2000 m while the bathymetry over central Bay of Bengal is relatively flat. For the morphological development of the fan, mass movement turbidity currents, sea level fluctuations and tectonics might have played a vital role. Morphologically the offshore Bengal Basin can be divided into Mahanadi, Krishna-Godavari and Cauvery offshore basins and intermediate non-basinal areas such as Visakhapatnam-Chilika Lake shelf and Madras-Pondicherry shelf [4]. The deltaic river processes mostly influence morphology of the offshore river grabens, mass movement and turbidity currents. "V" shaped Canyons, fan valleys and fault valleys are some of the prominent morphological features of these basins (Box 1 provides structural descriptions).

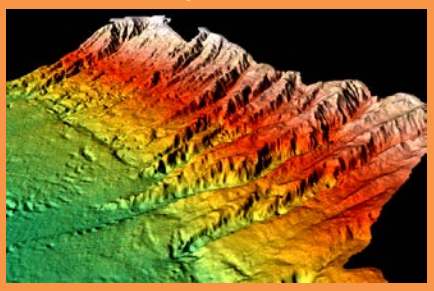
Seamount



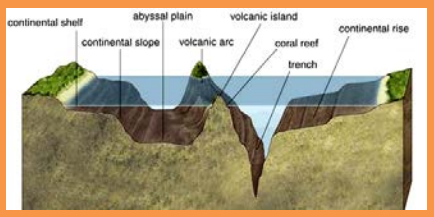
Graben



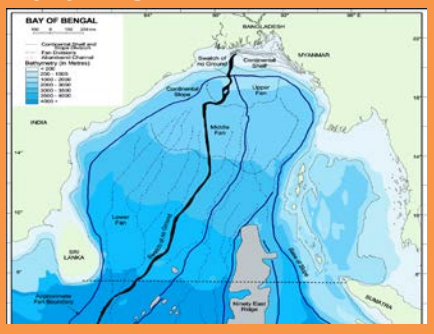
Submarine Canyon



Sea bottom Features

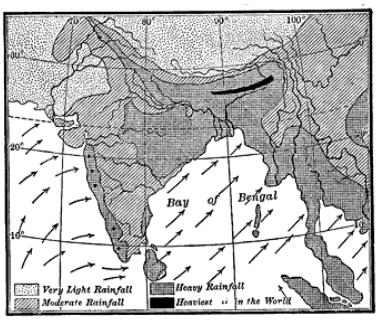


Bay of Bengal

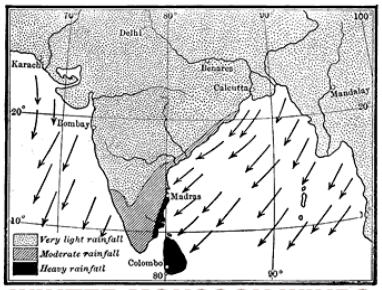


In the central Bengal fan the average depth of the seabed is ~3400 m, where several turbidity channels are noticed in the fan area and some of them are channel levee wedges of abandoned type [5]. The channel widths, in general, vary from 5 to 27 km in the Bengal Basin. The most important feature of the southern Bay of Bengal is the presence of a large number of bathymetric highs/ seamounts [4]. Thus, the Bengal Fan in general has a smooth topography, but there also exist several valley like features in the north and isolated highs in the southern Bay of Bengal.

Climate



SUMMER MONSOON WINDS



WINTER MONSOON WINDS

The climate of the Bay of Bengal is dominated by the monsoons (Box 2). According to the Indian Meteorological Organization (IMD), meteorological seasons over India are:

- Winter Season: January – February
- Pre Monsoon Season: March – May
- Southwest Monsoon Season: June - September
- Post Monsoon Season: October - December

From November through April a continental high-pressure system north of the bay produces northeast winds (the northeast monsoon) characteristic of the winter season. During the northern summer (June–September) the rain-bearing southwest monsoon prevails, as intense heat produces a low-pressure system over the continent and a subsequent air flow from the ocean.

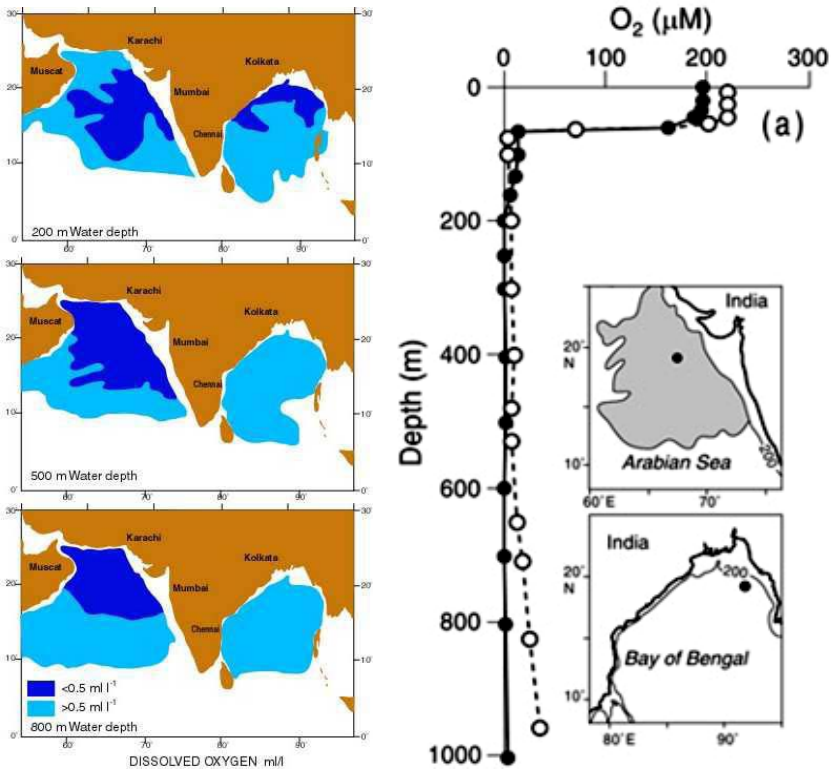
North east monsoon and cyclonic storms over the Bay of Bengal along South East coast of Peninsular India bring heavy rainfall associated with major physical changes. From January to October, the current is northward flowing, and the clockwise circulation pattern is called the "East Indian Current". The Bay of Bengal monsoon moves in a northwest direction striking the Nicobar Islands, and the Andaman Islands first, by end of May and then the north eastern coast of India by end of June. The remainder of the year, the counter-clockwise current is south-westward flowing, and the circulation pattern is called the East Indian Winter Jet. September and December see very active weather in the Bay of Bengal producing severe cyclones which affect the east coast of India. Strong winds produce storm surges in many parts of the coast. Changes in the frequency of tropical cyclones developing over the Arabian Sea and the Bay of Bengal have been studied [6] utilizing 122 year (1877-1998) data of tropical cyclone frequency. Significant increasing trends in the cyclone frequency over the Bay of Bengal have been observed during November and May which are main cyclone months. During

transitional monsoon months, June and September, however, the frequency has decreased.

Hydrology

A unique feature of the bay is the extreme variability of its physical properties. Temperature in the offshore areas, however, is warm and markedly uniform at all seasons, decreasing somewhat toward the north. Surface densities are considerably greater in post-monsoon than in premonsoon, when river discharge is highest [7]. Surface salinity, normally measuring 33 to 34, can fall to nearly half that level and can extend well south of the bay during premonsoon. Below the surface layer is an oxygen-poor intermediate layer that has high salinity and undergoes only weak circulation (Fig. 1.2). In the Bay of Bengal, there occurs a weak upwelling during the northeast monsoon.

Fig. 1.2: Oxygen Minimum Zone (OMZ) in the Bay of Bengal [8,9]

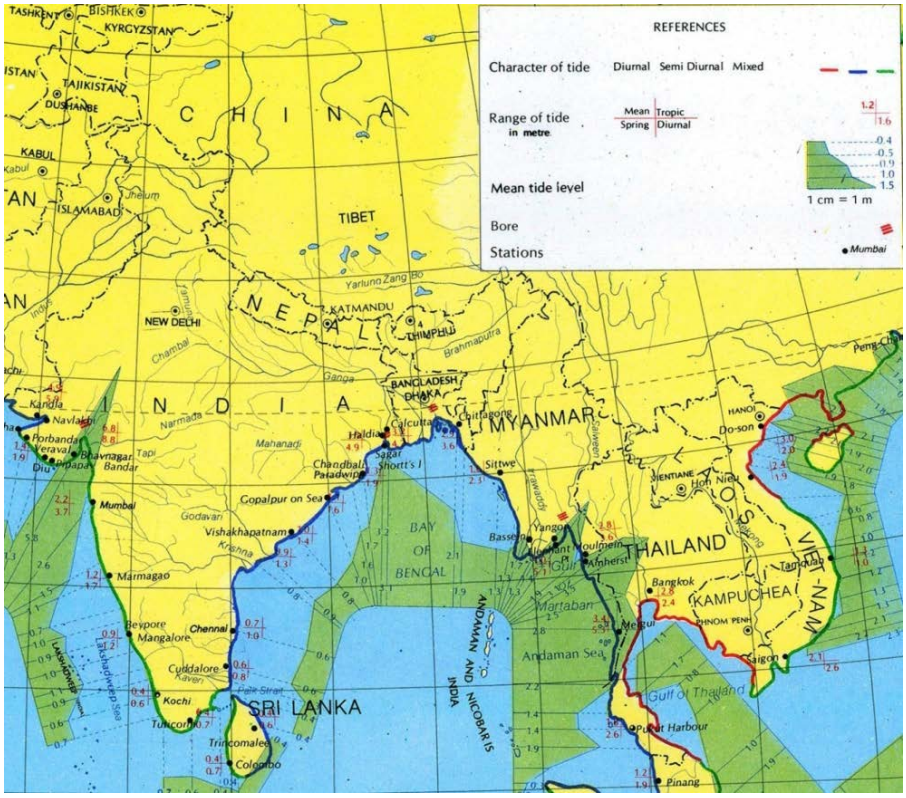


The sea presents alternately slick and ruffled surfaces over shallow internal waves along the east-coast shelf. Surface movements of the waters change direction with the season, the northeast monsoon giving them a clockwise circulation, the southeast monsoon a counter-clockwise circulation. Severe storms occur at the change of monsoon, particularly to the south in October [10].

In addition to water-level changes resulting from waves and tides, (Fig. 1.3) the average sea level varies throughout the year. The Tide Map (scale 1:25,000,000)

[11] shows (a) characters of tide, (b) range of tide, (c) mean tide level, and (d) tidal bore. In the Bay of Bengal region, because rainfall and riverine input exceed evaporation, the bay exhibits a net water gain annually. The bay is also subject to occasional tsunamis. One such event, caused by an undersea earthquake near the Indonesian island of Sumatra on 26 December 2004, devastated extensive coastal stretches of Tamil Nadu and Puducherry of mainland India and the Andaman and Nicobar islands in the Bay of Bengal region, as well as the other BoBLME countries including Sri Lanka, Thailand and Indonesia.

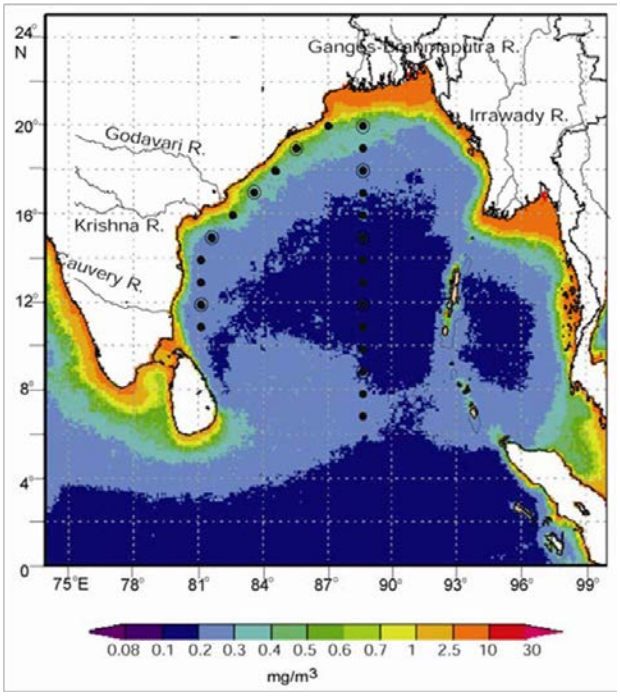
Fig. 1.3: Patterns and range of tides along the coast of the Indian Sub-continent (Source: Indian Ocean Atlas, 1998)[11]



Primary Productivity of the Bay of Bengal

Bay of Bengal has lower biological productivity due to the lack of upwelling, compared to the Arabian Sea. Although the riverine flux may bring in nutrients, they are thought to be lost to the deep because of its narrow shelf [11,12,13].

Fig. 1.4: Chlorophyll pigment concentration map[14]



Location of CTD (filled circle) and biological (small open circle) stations occupied along the central and western boundary of the Bay of Bengal during summer monsoon (6 July to 2 August 2001), fall (14 September to 12 October 2002), and spring (12 April to 7 May 2003) intermonsoons overlain on annual mean climatology (1998–2006) of chlorophyll pigment concentration (mg/m^3) obtained from SeaWiFS[18].

Recent measurements of chlorophyll, primary productivity (PP) and nutrients along the central Bay of Bengal (BoB) during summer, fall and spring intermonsoons showed that the northern bay becomes less productive compared to the south in summer and fall intermonsoon, in spite of the nutrient input to the upper ocean by way of river influx as well as eddy pumping[15]. Along the western boundary also, highest PP in the northern bay did not occur during summer or in the fall intermonsoon, but occurred in the spring intermonsoon. The reason for this was explored using diffuse attenuation [Kd(490)] and photosynthetically active radiation (PAR) which indicates the influence of the river flux in curtailing the downward penetration of solar radiation and cloud cover respectively. During summer and fall intermonsoon, biological productivity in the northern BoB is severely limited by the reduced downward penetration of solar radiation due to the large quantities of sediment brought by the adjoining rivers. Though the cloud cover reduces PAR in the northern BoB, this has only a secondary effect in comparison to the light limitation due to turbidity, which showed an order of magnitude increase in the northern Bay.

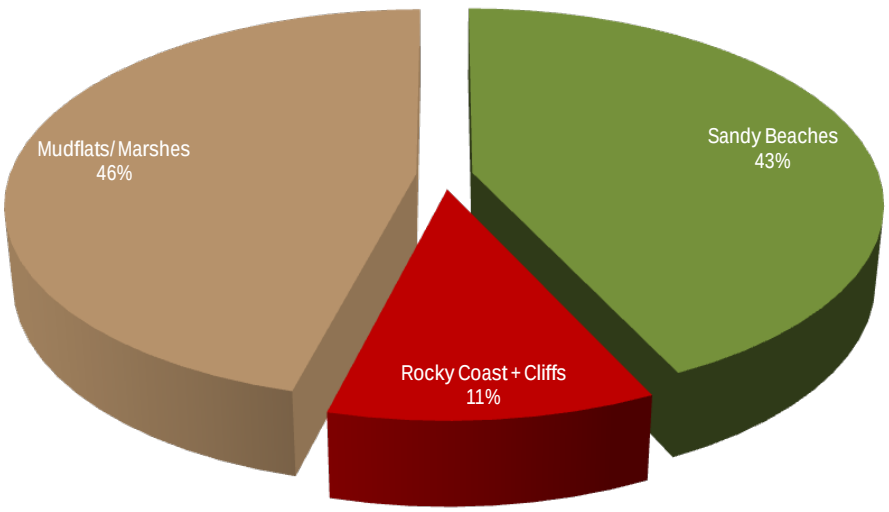
Comparatively heavier cloud cover during summer monsoon may be another reason for this [16]. Because it is a cyclone-prone region, these episodic events are likely to churn-up the area, injecting nutrients to the shallow euphotic zone (shallow due to cloud cover and turbidity arising from sediment influx) and thereby enhance production in the upper layers. It has also been postulated that higher surface production resulting from lower light intensities occurs in the Bay of Bengal although the column production is much higher in the Arabian Sea [15].

Primary productivity values ranging from 3.0 to 8.7 g C m^{-2} d^{-1} (>300 gC m^{-2} yr^{-1}) have been reported from the inshore waters of the east coast of India in June-July [17]. Based on measurements during August-September 1978 Chlorophyll a up to 50 mg m^{-2} was reported inshore [18]. These values are probably exceptional, often referring to inshore blooms. On the contrary, most measurements are in effect less than 0.5 g m^{-2} d^{-1} along with very low chlorophyll a (usually <0.1 mg m^{-3} or <10 mg m^{-2}). Details of algal blooms along the east coast of India are discussed in detail in Section 5.4 of this report. Large river runoff supports primary production in coastal waters and the central part of the Bay of Bengal is less productive due to absence of large scale upwelling [19]. Secondary production has been reported to be highest from October to January (winter monsoon period) and lowest from June through September (summer monsoon) [20]. The zooplankton biomass is low nearshore but increases towards the EEZ boundary. Coastal wetlands, marshes, coastal lagoons, backwaters and mangroves play an important role in the overall productivity of the Bay of Bengal.

India's coastline

India’s coast is 7517 km long; of this distance, 5423 km belongs to peninsular India, and 2094 km to the Andaman, Nicobar, and Lakshadweep Islands. India's extensive coast constitutes ~2.5% of the total geographical area with sandy beaches, mangroves, mud flats, coral reefs and marine algal and seaweed beds. According to the Indian Naval hydrographic charts, the mainland coast consists of the following: 43 % sandy beaches, 11 % rocky coast including cliffs, and 46 % mud flats or marshy coast (Fig. 1.5). The notable features of India’s east coast include the alluvial Sundarbans delta in the East, which India shares with Bangladesh and the many large river deltas such as Mahanadi and Cauvery. India’s island territory in the Bay of Bengal is the archipelagic Andaman and Nicobar Islands, a volcanic island chain in the Andaman Sea.

Fig. 1.5: Classification of Indian Coastline (Source: Indian Naval Hydrographic Charts)



The Andaman and Nicobar Islands constituting 0.3 % of the total geographical area is one of the three tropical moist evergreen forests zones in India. The elongated North-South oriented groups of 348 Andaman Islands have a biogeographical affinity with Myanmar. The Nicobar Islands, lying only 90 km away from Sumatra have much stronger Indonesian and South-East Asian elements. These islands are centres of high endemism and contain some of India's finest evergreen forests and support a wide diversity of corals.

1.2 Coastal Ecosystems of the Bay of Bengal Region

The mainland coastline of India is remarkably unindented and generally emergent. The east coast is generally shelving with beaches, lagoons, deltas and marshes. It is also relatively low lying with extensive alluvial plains and deltas. Coastal zones are not only economically valuable for fisheries, commerce, navigation and recreation, but also include some of the most ecologically important environments. Regrettably, these economic, social, and environmental benefits are at a risk as the coastal zones are affected by both gradual and recurrent processes such as accretion and erosion and by extreme natural events such as floods, tsunamis, cyclones and severe storms. This is further aggravated due to increased economic activity within the coastal zones resulting in costly damages to property, society, economy and environment. This combination of natural and human forces and the uncertainties involved in their origins and impacts presents major challenges to coastal managers. In the following sections of this chapter, some of the major coastal ecosystems such as mangroves, seagrasses, seaweeds, coral reefs, lagoons, estuaries and sand dunes are discussed in terms of their distribution, threats and management.

Mangroves

Mangroves are salt-tolerant forest ecosystems found in specific regions mainly in tropical and sub-tropical inter-tidal regions of the world. They are trees, shrubs or a variety of complex plant communities that have the common trait of growing in shallow and muddy salt water or brackish waters, especially along quiet shorelines and in estuaries.

Status of Indian Mangroves

Mangroves in India account for about 5 % of the world's mangrove vegetation and are spread over an area of about 4500 km^2 along the coastal States/UTs of the country. Sunderbans in West Bengal accounts for a little less than half of the total area under mangroves in India. The Forest Survey of India (FSI) is assessing the vegetation cover of the country including mangroves using remote sensing since 1983. It published its first assessment of mangroves of India in 1987 and estimated it to be 4946 km². Thereafter, mangroves were assessed regularly on a two-year cycle. State/UT wise mangrove cover as assessed by FSI in different assessments is given

in Table 1.1 [21]. Assessment of mangrove cover has also been categorised into very dense mangrove (canopy density of > 70%), moderately dense mangrove (canopy density between 40 and 70%) and open mangrove (canopy density between 10 and 40%).

Table 1.1:Mangrove cover assessment for the east coast of India (area in km^2)

S. No.	State/UT	Assessment Year and Area in km^2									
		1987	1989	1991	1993	1995	1997	1999	2001	2003	2005
1	Andhra Pradesh	495	405	399	378	383	383	397	333	329	329
2	Orissa	199	192	195	195	195	211	215	219	203	203
3	Tamil Nadu	23	47	47	21	21	21	21	24	36	36
4	West Bengal	2076	2109	2119	2119	2119	2123	2125	2081	2120	2118
5	Andaman Nicobar	686	973	971	966	966	966	966	789	658	637
Total		**3479**	**3726**	**3731**	**3679**	**3684**	**3704**	**3724**	**3446**	**3346**	**3323**

Fig. 1.6: Mangrove cover assessment (extent) for the east coast of India (area in km^2)

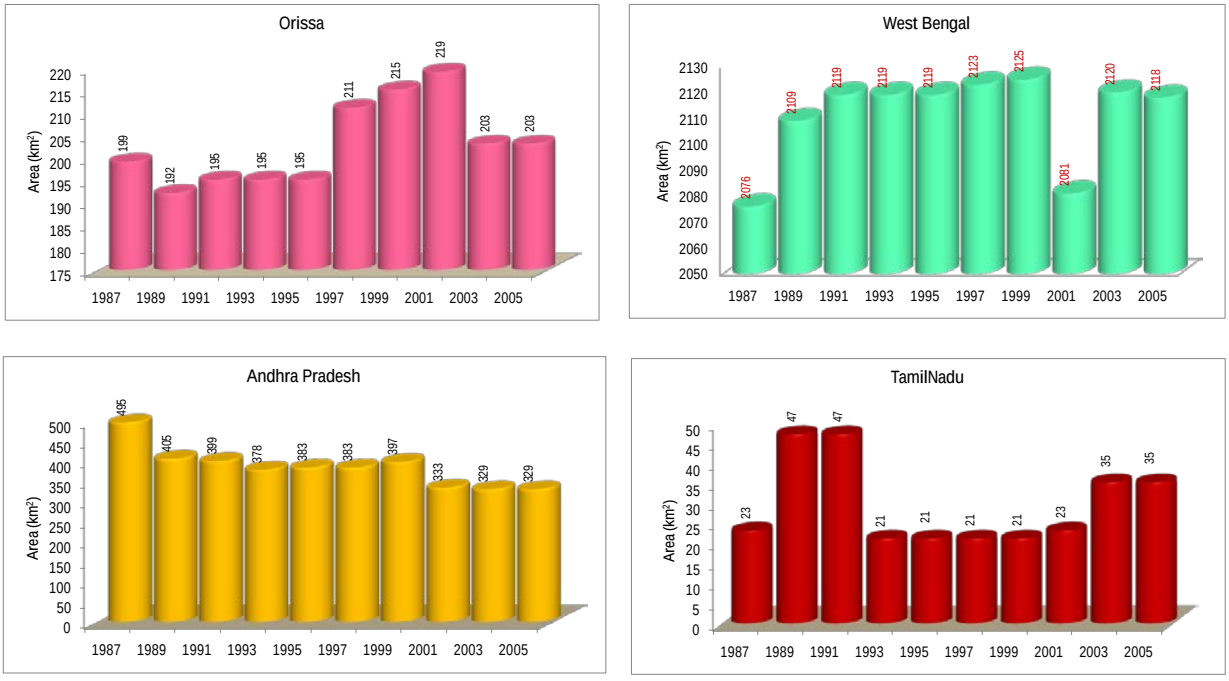


Table 1.2: Mangrove cover assessment (density) for the east coast of India (area in km^2)

S. No.	State/ UT	Very Dense Mangrove	Moderately Dense Mangrove	Open Mangrove	Total	Change w.r.t. 2001 assessment
1	Andhra Pradesh	0	15	314	329	-4
2	Orissa	0	160	47	207	-12
3	Tamil Nadu & Puducherry	0	18	18	36	12
4	West Bengal	892	894	334	2120	39
5	Andaman Nicobar	262	312	97	671	-118
	Total	**1154**	**1399**	**810**	**3363**	**-83**

According to the Forest Survey of India out of 4,87,100 ha of mangrove wetlands in India, nearly 56.7 % (2,75,800 ha) are present along the east coast, 23.5% (1,14,700 ha) along the west coast and the remaining 19.8 % (96,600 ha) are found in the Andaman and Nicobar Islands. On a macro scale, geomorphic settings of the mangrove wetlands of the east coast of India are different from those of the west coast. Mangrove wetlands of the east coast are larger, high in diversity and water-bodies associated with mangroves are characterized by the presence of larger brackish water-bodies and a complex network of tidal creeks and canals compared to the mangroves on the west coast of India. This is mainly due to larger deltas created by east flowing rivers and gentle slope of the coast.

Fig. 1.7: Common mangrove species in the Bay of Bengal coast

a) Rhizophora Sp.

b) Avicennia Sp.

The Indian Mangroves are classified into three types: *1) deltaic mangroves, 2) estuarine- backwater mangroves and 3) insular mangroves*. Deltaic mangroves are distributed on the east coast of India. The estuarine and backwater mangroves are found on the west coast. Insular mangroves are found on the islands of India. The Indian mangroves are represented by approximately 59 species (inclusive of some mangrove associates) from 29 families. The east coast is represented by 48 species belonging to 32 genera. The east coast of India and the Andaman and Nicobar Islands show high species diversity as well as unique distribution of mangrove flora.

Table 1.3:Distribution of Mangroves in the Bay of Bengal coast of India

State	District	Site
Tamil Nadu	Cuddalore	Pichavaram
	Nagapattinam	Muthupettai
	Thanjavur	Athirampattinam and Thuraikadu
		Koraiyar and Marakoraiyar
	Pudukottai	Mimisal
	Ramanathapuram	Karankadu, Uppuchatram, Uppur, Mokeppanai, Vennatur
Andhra Pradesh	East Godavari	Godavari delta
	Krishna	Krishna delta
Orissa	Ganjam	Bahuda and Rushikulya estuarine mangroves.
	Puri	Chilika lake, Balighai, Konark, Jagatsinghpur
West Bengal	South 24 Parganas	Sunderbans

Table 1.4:State/ UT-wise Mangrove Cover Assessment (2001)

S. No.	State/UT	Dense	Open	Total	% Geographical Area (km^2)
1	Andhra Pradesh	14	319	333	0.12
2	Orissa	194	25	219	1.39
3	Tamil Nadu	10	13	23	0.02
4	West Bengal	1651	430	2081	2.34
5	Andaman and Nicobar	709	80	789	9.56
6	Puducherry	0	1	1	0.21
Total		**2578**	**868**	**3446**	**13.64**

Threats to mangrove ecosystems

Threats to the mangrove ecosystems could be broadly classified as natural and anthropogenic. These may affect the system as a whole or any one or more entities within the system. Briefly, the major threats are:

Natural

- Cyclones
- Earthquakes
- Tsunami
- Reduced freshwater flow and consequential high saline condition
- Sea level rise and consequently higher salinity conditions

Anthropogenic

- Habitat destruction and loss of biodiversity
- Encroachment resulting in shrinkage of area
- Uncontrolled dredging resulting in succession changes
- Uncontrolled siltation and weed infestation. The spread of the invasive *Prosopis juliflora* is a threat to the future of the mangroves.
- Pollution from point and non-point sources resulting in deterioration of water quality
- Uncontrolled discharge of waste water, industrial effluents, surface run-off etc. resulting in proliferation of aquatic weeds which has detrimental effect on flora and fauna

Seagrass Ecosystems

Seagrasses are valuable and overlooked habitats, providing important ecological and economic components of coastal ecosystems worldwide. Seagrasses are a functional group of about 60 species of underwater marine flowering plants. They grow on soft substrates like sandy soils and form large underwater meadows in coastal regions of the world. Thousands more associated marine plant and animal species utilize seagrass habitat. They provide habitat for fish and shellfish and serve as nursery areas to the larger ocean. They perform important physical functions of filtering coastal waters, dissipating wave energy and anchoring sediments. Seagrasses often occur in proximity to, and are ecologically linked with, coral reefs, mangroves, salt marshes, bivalve reefs and other marine habitats. Seagrasses are the primary food of manatees, dugongs and green sea turtles, all threatened and charismatic species of great public interest. Seagrasses function as stabilizers and sediment accumulators of inter tidal and sub tidal areas of the coast.

Seagrass Ecosystems in India

The major sea grass meadows in India exist along the southeast coast (Gulf of Mannar and Palk Bay) and in the lagoons of Islands from Lakshadweep (Arabian Sea) and Andaman and Nicobar Islands (Bay of Bengal). The flora comprises 14 species and is dominated by *Cymodocea rotundata, Thalassia hemprichii*, and *Halophila beccarii* of which 13 species occur in the Gulf of Mannar [22].

Fig.1.8: Seagrass ecosystems in India

Threats to Seagrass Ecosystems

Seagrasses are subject to many threats, both anthropogenic and natural. Runoff of nutrients and sediments from human activities on land has major impacts in the coastal regions where seagrasses thrive; these indirect human impacts, while difficult to measure, are probably the greatest threat to seagrasses worldwide. Both nutrient and sediment loading affect water clarity; relatively high light requirements make seagrasses vulnerable to decreases in light penetration of coastal waters. Direct harm to seagrass beds occurs from boating, land reclamation and other construction in the coastal zone, dredge-and-fill activities and destructive fisheries practices. Human induced global climate change may well impact seagrass distribution as sea level rises and severe storms occur more frequently.

Seaweed Ecosystems

Seaweeds refer to any large marine benthic algae that are multicellular, macrothallic, and thus differentiated from most algae that are of microscopic size. These plants form an important renewable resource in the marine environment and have been a part of human civilization from time immemorial. They belong to the groups of red algae, green algae, and brown algae and are most commonly found in the littoral zone. Many of the rocky beaches, mudflats, estuaries, coral reefs and lagoons of this zone along the Indian coast provide ideal habitats for the growth of seaweeds.

Fig. 1.9 Representatives of Seaweed Species

Seaweeds: Chlorophyta **Rhodophyta** **Phaeophyta**

Seaweeds of India

The seaweed flora of India is highly diversified and comprises mostly of tropical species, but boreal, temperate and subtropical elements have also been reported.

Table 1.5: Distribution of seaweed resources along the coastal states of India [23]

State	**Location**
Tamil Nadu (Including Puducherry)	Krusadai Island and Idinthakarai
Andhra Pradesh	Visakhapatnam and Pulicat lake
Orissa	Chilika lake
West Bengal	Sundarbans
Andaman and Nicobar Islands	All islands

In all, 770 species of Indian seaweeds have been reported which include 184 species of green, 166 species of brown and 420 species of red algae [24]. The southern coast of India bears luxuriant growth of seaweeds. More than 200 species of seaweeds have been found in this area. The present uses of seaweeds are as human foods, cosmetics, fertilizers, and for the extraction of industrial gums and chemicals (agar) and they have the potential to be used as a source of long- and short-chain chemicals with medicinal and industrial uses. In India, agar resources, as annual yield of dry sea weed, have been estimated to be about 4.06 - 5.08 metric tonnes for Chilika Lake, about one metric tonne for Kanyakumari, and about seven metric tonnes for the Pamban area. In addition, the resources of the Andaman Islands are believed to be considerable.

Threats to Seaweed Ecosystems

The multiple and conflicting uses of seaweed habitats, dredging, illegal exploitation of seaweeds, trawl net operation over the seaweed beds, siltation and sedimentation by erosion and accretion process and deepening harbour areas are the major threats to the seaweed ecosystems in India. Alteration of major ecosystems like estuaries, mangroves and coral reefs is also affecting the seaweeds distribution. With the growing demand for raw material of agar yielding seaweeds from agar industries, there is overexploitation of the agarophytes *Gelidiella acerosa* and *Gracilaria edulis*. Construction of structures along the coast which cause erosion and accretion also affect distribution of seaweeds.

Coral Reefs

Coral reefs are shallow water, tropical marine ecosystems which are characterized by a remarkably high biomass production and a rich faunal and floral diversity perhaps unequalled by any other habitat. The corals exhibit extensive biodiversity in

structure and forms. Coral islands as well as coral reefs are secretory products of the skeleton forming Cnidarians. The term 'Corallum' is the total coral bush and the 'Corallite' is the calcareous cup within which the coral polyps, the living element remain embedded.

The total coral reef area in India is 5,790 km^2, distributed between four major regions, of which, two - Gulf of Mannar and the Andaman and Nicobar Islands - are in the Bay of Bengal region. Reef structure and species diversity vary considerably between the areas due to differences in the reef extent and geo-environmental conditions. In India, a total of 206 coral species have been reported [25]. Among the coral regions of the country, the Andaman Islands reported the maximum (i.e. 135 species) with other areas falling in between with respect to species richness.

Fig 1.10: Coral Reefs of India

Table 1.6:Coral Reef ecosystems of India [26]

Coral Reef Region	Genera	Species
Gulf of Mannar and Palk Bay	37	94
Andaman & Nicobar Islands	59	135
West Coast of Kerala & Tamil Nadu	17	29
Total for India	37	199

Threats to Coral Reefs

Human activities, both direct and indirect, are driving the loss of coral reefs. These include over-fishing, particularly of long-lived, low density fish such as grouper, and destructive fishing practices such as the ubiquitous use of cyanide and dynamite to capture fish. Pollution, especially from increased sedimentation (from poor land use) that smothers the coral tissue and nutrients (from runoff) that promote algae growth which in turn, suffocate the corals, is a major problem. Some of the threats include:

- Physical damage to corals by tourists damaging the reefs
- Anchors dropped in coral beds and
- Ships colliding with reefs
- Alteration of coastline/ Island habitats such as deforestation

- Coastal development
- Harvesting live aquarium fish and coral for food, traditional medicine, and aquaria.

In mainland India there is continuous damage to coral reefs from human activities such as the use of destructive fishing methods, over harvesting of resources, development and pollution, while in the Andaman and Nicobar Islands, these threats are much lower. However, climate change poses a serious threat to all reefs in the region. All coral reef areas continue to be under stress, especially in the Gulf of Mannar where coral mining and destructive fishing practices are most prevalent.

Coastal Lagoon

A coastal lagoon is a shallow coastal water body separated from the ocean by a barrier, connected at least intermittently to the ocean by one or more restricted inlets and usually oriented shore-parallel. Coastal lagoons, which occupy as much as 13% of the world's coastline are very rich natural systems but, at the same time, very fragile ecosystems. They are extensively used as harbours, recreation areas and for their mineral resources. Lagoons are highly productive and used for raising selected species of prawns and fish species.

Lagoons of India

A number of lagoons are present on the east and west coasts of India. The important ones on the east coast are the Chilika (Orissa) and Pulicat (Tamil Nadu). Other important lagoons on the east coast are listed in Table 1.7.

Table 1.7:Lagoons along the East Coast of India. [27]

Coastal Lagoons on the East Coast of India	
Chilika lagoon	**Orissa**
Pulicat lagoon	**Andhra Pradesh-Tamil Nadu**
Pennar lagoon	
Bendi lagoon	**Andhra Pradesh**
Nizampatnam lagoon	**Andhra Pradesh**
Muttukadu lagoon	**Tamil Nadu**
Muthupet lagoon	**Tamil Nadu**

Fig 1.11: Lagoons of the east coast of India

Chilika Lagoon Pulicat Lagoon

Threats to coastal Lagoons

The threats affecting the lagoon ecosystems are the following;

- Degradation due to siltation (of the aquatic ecosystems)
- Increased urban activities resulting in air, water and soil pollution
- Extensive growth of aquatic weeds resulting in deoxygenation
- Coastal and soil erosion
- Indiscriminate land use, abuse and misuse and
- Untimely and injudicious dredging of the waterways (if any dredging was carried out).

Estuaries

An estuary is an integral part of the coastal environment. It is the outfall region of the river, making the transitional zone between the fluvial and marine environs. It is a semi-enclosed coastal body of water which has a free connection with the open sea and within which the sea water is measurably diluted with the fresh water derived from land drainage [28].

Estuaries in India

In India, there are around 113 major and minor estuaries which have the combined river length of 45000 km. The east coast estuaries are comparatively long running than the estuaries of the west coast. The estuaries of India are mostly positive estuaries and the sizes of the estuaries vary. Hence the estuaries have been classified based on the drainage area viz., major, medium, and minor estuaries.

Major estuaries in India

Some of the major Indian estuaries on the east coast are:

- The Ganges estuary and delta
- Mahanadi
- Godavari
- Krishna
- Cauvery

Table1.8: Medium Estuaries of the East Coast of India.

Andhra Pradesh	Baitarni, Matai and Rushikulya estuary.
	Thottapalli
	Koratalaiyar, Pallar, Ponnaniyar, Vellar, Vaigai, and Tambraparani

Minor Estuaries

The minor river basins have a drainage area of less than 2,000 km² each. Some of the minor estuaries on the east coast are Gosthani estuary in Andhra Pradesh, Adyar, Ennore, Cooum, Agniyar, Pinnakayal estuary and Muttukadu backwaters in Tamil Nadu.

Threats to Estuaries

Many development activities change the salinity, temperature and nutrients in the estuaries and thus create stress on the ecosystem. Over fishing and artificial introduction of species also lead to the imbalance of the estuarine ecosystem. Human interference in these aquatic bodies has caused considerable ecological imbalance and resulted in large-scale disappearance of their flora and fauna. Introduction of untreated municipal waste water and industrial effluents into these water bodies lead to serious water pollution including heavy metal pollution, which gets biomagnified and reaches man through food chain implications.

Sand Dunes

Sand dunes are small ridges or hills of sand found at the top of a beach, above the usual maximum reach of the waves. They form from windblown sand that is initially deposited against an obstruction such as a bush, driftwood or rock. As more sand particles are deposited the dunes grow in size, forming rows at right angles to the

prevailing wind direction. Sand dunes can be important ecosystems supporting unique plant life and a healthy population of small animals and insects.
Fig 1.12 : Coastal Sand Dunes

Threats to Sand Dunes

Dunes are very vulnerable to erosion by natural processes and by human activity. It is common to see vulnerable sections of dunes fenced off to prevent public access, or for paths to be laid to prevent people from eroding the dunes. Coastal dunes have been and are used for a variety of purposes including mining (both placer mining and sand extraction), water extraction, waste water disposal, housing, agriculture and recreation. Problems that have arisen from some of these uses include sand drift, shoreline recession, soil over-nutrification, loss of species, destruction of archaeological sites and reduced recreational amenity. Some of the factors responsible for dune degradation are

- Construction activities
- Sand extraction
- Construction of roads
- Recreation activities
- Litter on beaches
- Salt water ingress

1.3 Coastal activities of high economic value in terms of GDP

Coastal activities such as ports and shipping harbours, aquaculture, agriculture, tourism, oil and mineral exploitation contribute about 10% of the national GDP. Goldman Sachs in its recent publication [29] has mentioned environmental quality improvement as one of the ten priorities for India for achieving its 2050 potential.

Major Coastal Activities (Drivers) of the Bay of Bengal Region

Ports and Harbours: Approximately 95% of the country's trade by volume and 70% by value is moved through maritime transport. There are eight major ports on the Bay of Bengal coast and fifty three minor ports as listed in Table 1.9 below (Also see Figure 1.13). A number of new ports are also coming up in this region. The capacity of major ports has increased from 574.77 million tonnes as on 31st March, 2009 to

616.73 million tonnes as on 31st March, 2010. The major ports handled a total traffic of 530.53 million tonnes during the financial year 2008-09 and 411.95 million tonnes up to December 2009 in the financial year 2009-10 [30].

Table 1.9: Major and Minor Ports along the East Coast of India

State	Major Port	Minor Port
West Bengal	2 (Kolkata, Haldia)	1
Orissa	1 (Paradip)	2
Andhra Pradesh	1 (Visakhapatnam)	12
Tamil Nadu	3 (Ennore, Chennai, Tuticorin)	15
Puducherry	-	1
Andaman & Nicobar Islands	1 (Port Blair)	22

Fig 1.13: Ports along the east coast of India

Energy/Power: A number of power plants are located along the Bay of Bengal coast. The preference for the coast is due to the high volume of water for cooling that is required as the energy sector has mainly focused on coal fired thermal and nuclear power plants along the coast. Many refineries and oil terminals are also located along the coastline as indicated in Figure 1.14.

Fig 1.14: The Energy Map of the east coast of India

Tourism: Two large lagoons are located on the east coast of India, the Pulicat lagoon on the border of Andhra Pradesh and Tamil Nadu, and Chilika in Orissa. Both lagoons are rich in biodiversity and attract ornithologists as well as wild life enthusiasts from all over India and the world. The Sunderbans in West Bengal are the largest single stand of halophytic mangroves, and apart from these, places like Coringa mangroves in Andhra Pradesh and Pichavaram in Tamil Nadu have large mangrove stands with high biodiversity and therefore, high ecotourism potential.

In addition, there are many important places of cultural tourism; standing out among them are Puri and Konarak in Orissa, Puducherry (Union Territory), and Mamallapuram, Poompuhar, Tranquebar and Kanyakumari in Tamil Nadu. A number of beaches are located along the east coast and some of the famous ones are the Digha in West Bengal, Puri-Konarak in Orissa, stretches near Visakhapatnam in Andhra Pradesh and the Marina beach in Chennai. The tourism sector is developing actively with the promotion of eco-tourism and beach resorts.

Fig 1.15 Location Map of tourist spots in East Coast of India

Agriculture: Intensive agriculture is practiced along the east coast especially because of the large deltas that exist in this region. The main crop is paddy but other crops such as pulses and oil seeds are also cultivated. Cash crops like cotton and jute (especially in West Bengal and Orissa) are also grown. Coconut is grown along the coast in almost all the states and union territories. An example of the district wise cropped area of coastal districts in Orissa is provided in the table below. The situation is similar in other states.

Table 1.10: District wise gross cropped area during 2004-05 (area in '000 hect.)
Source: www.cesorissa.org

S. No.	Name of the District	Paddy	Other Cereals	Total Cereals	Total Pulses	Total Food Grains	Total Oil Seeds	Total Vegetables	Total Spices	Total Fibres	Sugar-cane	Fruits
1	Balasore	240.3	0.9	241.3	20.3	261.5	15.0	31.7	7.1	3.0	0.1	7.3
2	Bhadrak	178.2	0.3	178.5	20.4	198.9	3.1	23.4	3.7	0.7	0.5	8.0
3	Ganjam	259.7	57.5	317.1	180.8	497.9	49.6	46.3	5.1	5.5	2.5	34.7
4	Jagatsinghpur	97.2	0.5	97.7	46.5	144.2	11.7	20.2	5.5	0.0	1.0	5.3
5	Khurda	110.7	1.1	111.8	43.0	154.9	3.8	27.4	1.6	0.3	0.7	20.9
6	Puri	172.2	0.4	172.6	45.2	217.8	11.8	17.0	1.0	0.0	0.4	18.4
7	Kendrapara	136.9	0.6	137.5	70.7	208.2	12.7	19.9	6.7	1.9	0.3	5.1

A number of problems have been created due to agricultural practices including waterlogging and salinization of land due to excess irrigation and poor drainage; fertilizer usage that causes non-point source pollution and results in eutrophication of coastal waters and overuse of groundwater as well as its pollution.

Aquaculture: Shrimp aquaculture is practiced mainly in Orissa (Chilika lagoon), Andhra Pradesh and Tamil Nadu. Aquaculture was popularized to bring in the Blue Revolution and while it has brought prosperity for some, it has been increasingly seen to be a problem industry because of unsuitable locations and unscientific practices in some cases. In some places, shrimp farms have come up in mangrove areas and have also resulted in salinisation of the surrounding land, depletion of groundwater, release of inorganic nutrients as well as antibiotics and exotic species.

Fisheries: Marine fisheries are an important traditional livelihood along coastal India and also contribute to the protein component of food. The marine fisheries sector has a very high population along the east coast. Traditional fishermen belong to specific castes and have their habitations very close to the shoreline. A variety of craft and gear combinations are used to catch fish. Information regarding the marine fishing sector along the east coast is provided in Table 1.11. Fish landing centres along the coast have been mapped in the Figure 1.16.

Table 1.11: Marine fishing sector along the east coast

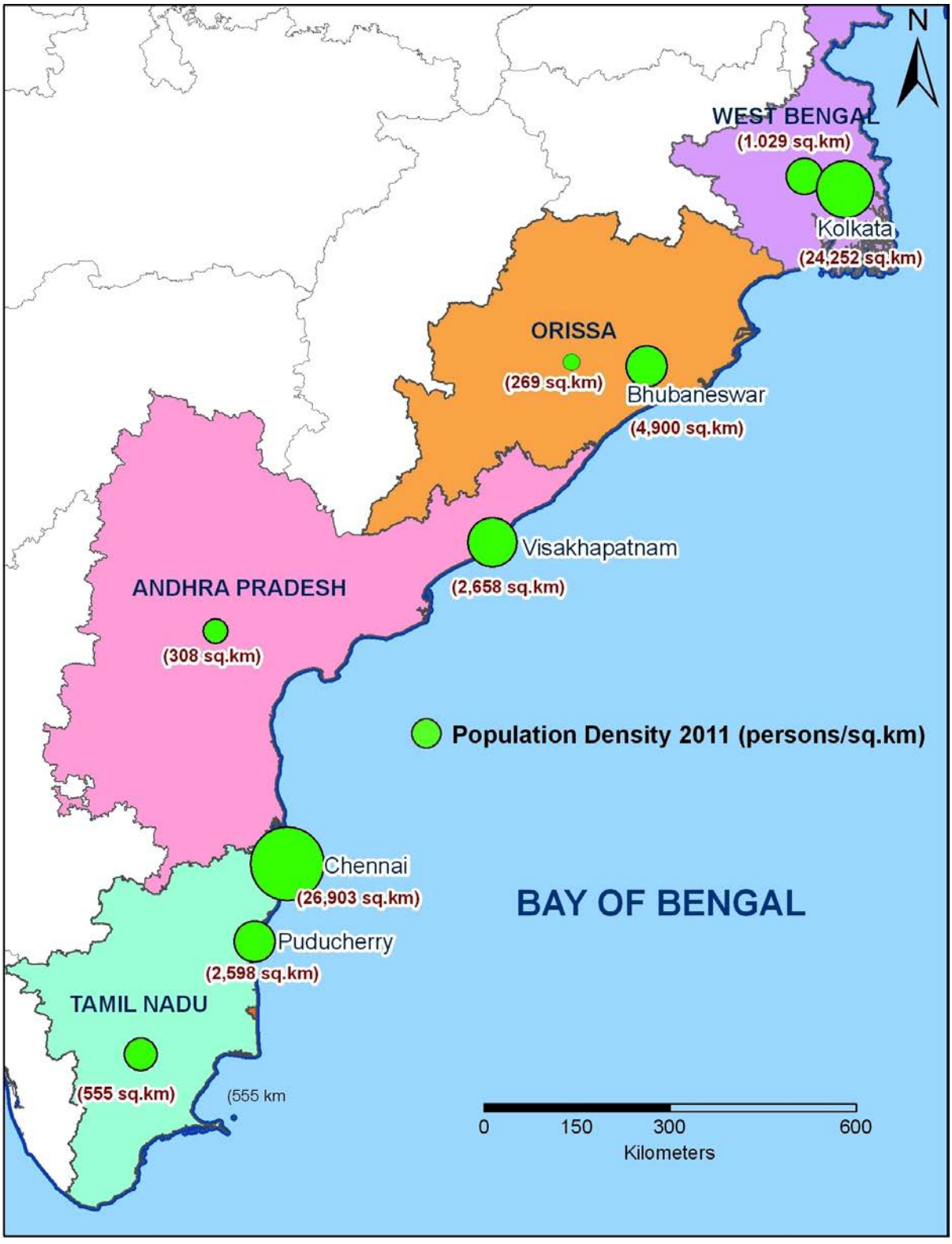
S.No.	Details of Fisheries	West Bengal	Orissa	Andhra Pradesh	Tamil Nadu	Puducherry
1.	Average Landings (2005) thousand tonnes	168.20	77.97	174.14	355.45	15.14
2.	Landing centres	44	57	271	352	26
3.	Fishing villages	346	641	498	581	28
4	Fisherfolk families	53,816	86,352	129,246	192,152	11,541
5	Fisherfolk Population	269,565	450,391	509,991	790,408	43,028

Fig 1.16 Location Map of Fish Landing Centers in East Coast of India

Industries: A number of industries are located along the coast in all the states though the extent of industrialization may not be as much as the west coast. Industrial clusters have been set up in each state. Some of the more industrialized areas along the coast may be seen around Visakhapatnam in Andhra Pradesh and Cuddalore in Tamil Nadu. In addition to various manufacturing industries, salt production from seawater is seen in certain areas. Tamil Nadu ranks second in India in salt production, and Tuticorin in Tamil Nadu is the highest producer of salt in the state.

Urbanization: Many towns and cities are located on the east coast. Major cities include Kolkata in West Bengal, Visakhapatnam in Andhra Pradesh and Chennai in Tamil Nadu. Among the states on the east coast, Tamil Nadu is the most urbanized. The population density is high along the coast as can be seen from the graphic below.

Fig. 1.17: Population density along Indian coast (based on Provisional Census data for 2011)



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CHAPTER 2: OVERVIEW OF SOURCES OF POLLUTION

2.1 Land based Pollution (Both point and non-point sources of pollution)

Marine Pollution: Definition (GESAMP)[1]

"Introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of quality for use of sea-water, and reduction of amenities."

Water pollution affects a nation's estuaries, coasts, oceans and rivers, making it a widespread and global concern. Coastal waters are subject to cumulative impacts from a variety of pollutants— from land through point and non-point sources, from the oceans and atmospheric sources. In India, there has been a growing awareness on controlling pollution from point sources but this has had limited success. This would also require a drastic reduction in pollution from non-point sources, which is a major technical challenge.

Classification of Pollution

Coastal waters are affected by both point and nonpoint sources of pollution, with the latter a significant and, in many cases, dominant form of pollution impacting coastal water bodies.

a) Point source Pollution:

Any discernible, confined, and discrete conveyance, including but not limited to, any pipe, channel, container, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged is referred to as point source. This term does not include return flows from irrigated agriculture or agricultural storm water runoff [2]. In India, the major point sources of pollution include wastewater (sewage - treated and untreated), septic systems and industrial outfalls.

b) Non-Point Sources

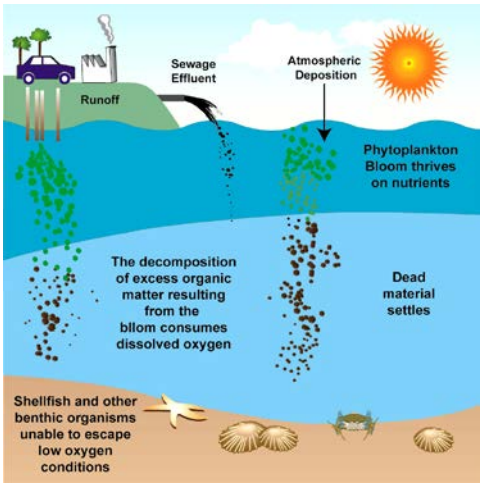
Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. As the runoff moves, it picks up and carries away natural pollutants and pollutants resulting from human activity, finally depositing them into lakes, rivers, wetlands, coastal waters, and ground waters. In addition, hydrologic modification is a form of nonpoint source pollution that often adversely affects the biological and physical integrity of surface waters [3].

Coastal waters in India receive a variety of land-based water pollutants, ranging from petroleum wastes to pesticides to excess sediments. Surface runoff from agriculture, aquaculture, and urban runoff are prominent non-point sources. Each of these pollutants independently, or in combination contributes to the degradation or destruction of marine habitats. For example, nutrient-rich waters can cause a proliferation of algae and phytoplankton to thrive in coastal areas that have the potential to create hypoxic conditions by using all available oxygen (Fig. 2.1). A compilation of the type and quantum of pollutants into the coastal ecosystem of India is given below:

Table 2.1: Type and quantum of pollutants discharged into the coastal ecosystem of India [4]

Input / Pollutant	Quantum - Annual
Sediments	1600 million tonnes
Industrial effluents	50 x 10^6 m^3
Sewage - largely untreated	410 x 10^6 m^3
Garbage and other solids	34 x 10^6 tonnes
Fertilizer – residue	5 x 10^6 tonnes
Synthetic detergents – residue	1,30,000 tonnes
Pesticides – residue	65,000 tonnes
Petroleum hydrocarbons (Tar balls residue)	3,500 tonnes
Mining rejects, dredged spoils & sand extractions	0.2 x 10^6 tonnes

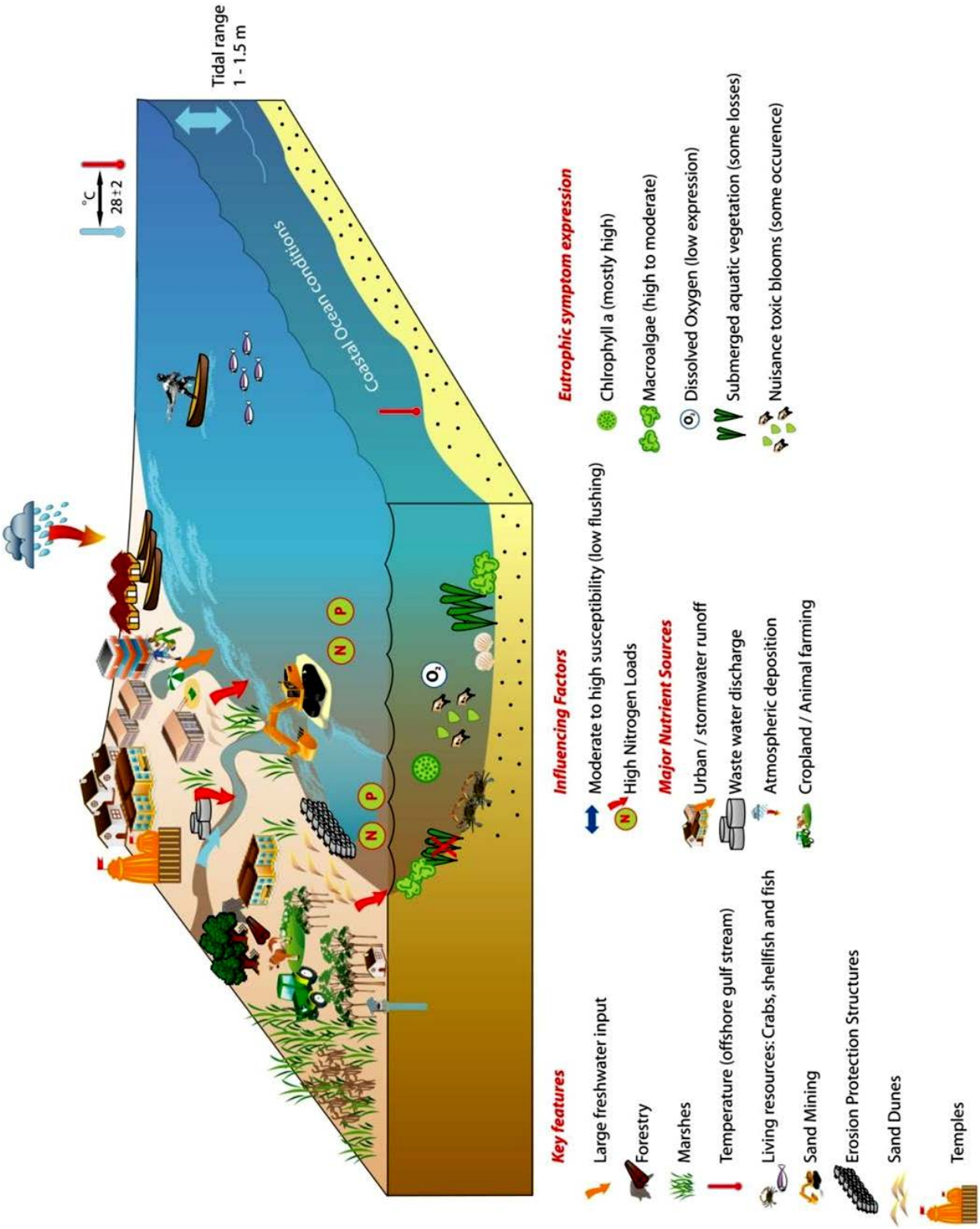
Fig. 2.1: Causes and consequence of pollution in coastal waters [5]



When ocean water becomes enriched in dissolved nutrients, from sources such as agricultural runoff and sewage outflows, the growth of phytoplankton is stimulated. As the phytoplankton die and sink to the bottom, their decomposition consumes the dissolved oxygen that other benthic organisms need to survive, sometimes resulting in mass fish kills.

The high concentration of activities in coastal areas, combined with pollutants flowing from streams far inland and others carried by air far away from their source are the primary causes of nutrient enrichment, hypoxia, harmful algal blooms, toxic contamination, sedimentation, and other problems that plague coastal waters (Fig. 2.2).

Fig. 2.2: Conceptual diagram of major land based activities along the coast of India



Nutrient Pollution in Coastal Waters

Although nutrients such as nitrogen and phosphorus are necessary for marine ecosystems in small quantities, human activities on the coasts and inland areas have greatly increased the flow of nutrients, in some cases to harmful levels. Nutrient pollution cannot be categorized easily and is difficult to control because it can come from point, nonpoint, and from atmospheric sources. Human activities have approximately doubled the amount of reactive nitrogen cycling through the biosphere compared to preindustrial conditions, with most of this increase occurring during the last three decades [6].

Fig. 2.3: Location of Major Sewage Outfalls along the east coast of India

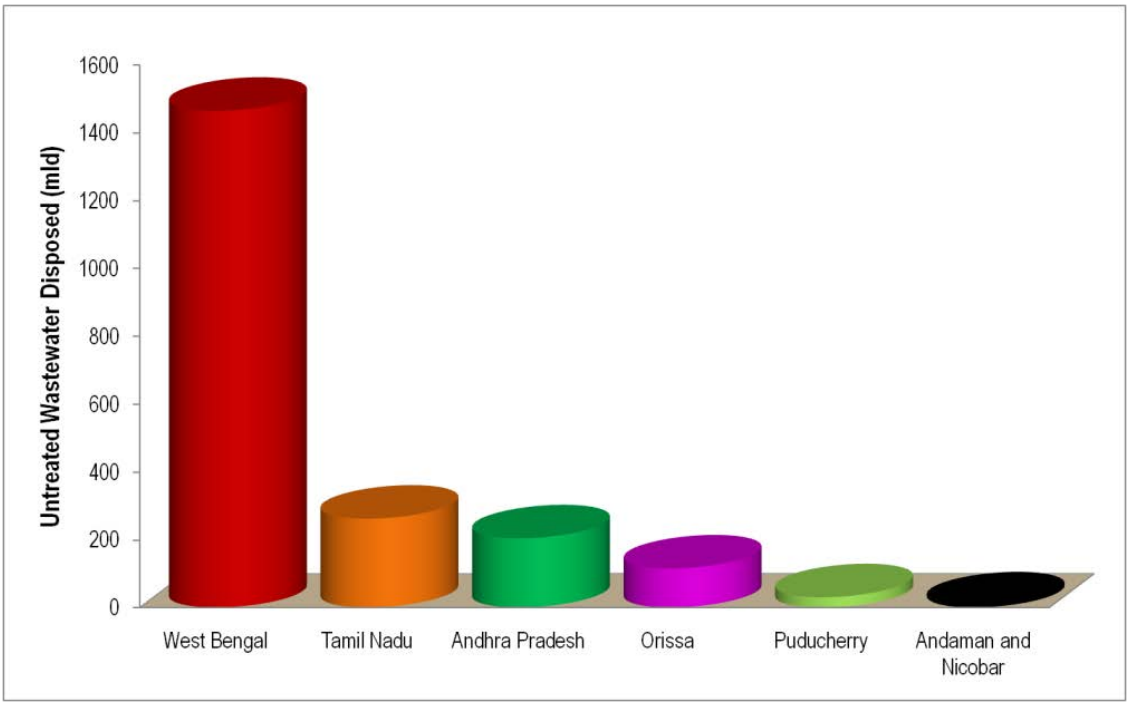
Consequences of addition of sewage to coastal waters

In India, the largest human additions of nitrogen result from both point and nonpoint sources. Point sources of nitrogen input are through sewer outfalls into the coastal waters and nonpoint sources are through the increased use of inorganic fertilizers. Several instances of high nutrient pollution have resulted in a host of ecological and economic impacts including:

- fish kills due to oxygen depletion;
- loss of important and sensitive coastal habitats
- excessive, and sometimes toxic, algal blooms;
- changes in marine biodiversity;

The greatest impacts occur in estuaries and nearby coastal regions. The Indian coastal waters also receive large quantities of municipal wastewater from its coastal cities and towns (Figure 2.4). Municipal wastewater constitutes the largest single source of coastal marine pollution [7].

Fig. 2.4: Untreated wastewater disposed to the coastal Bay of Bengal (Source: CPCB, 2002) [8]



Hypoxia and Anoxia due to sewage inputs

Dissolved oxygen depletion in coastal and estuarine waters is a growing global concern. Bottom water dissolved oxygen (DO) concentrations are near zero under anoxic conditions, whereas they are < 2.0 mg l^{-1} under hypoxic conditions. In aquatic

ecosystems, hypoxia refers to a depletion of the concentration of dissolved oxygen in the water column from what can be near 9 mg l^{-1} (roughly the maximum solubility of oxygen in estuarine water on an average summer day), to below 2 mg l^{-1}. If hypoxic conditions are reached, these local, atypically low oxygen conditions can profoundly affect the health of an ecosystem and cause physiological stress, and even death, to associated aquatic organisms.

While hypoxia can occur naturally, periodic occurrence of hypoxia, and the more extreme condition of anoxia (a total loss of dissolved oxygen), may indicate a stressed environment resulting from a systemic problem of an overabundance of nutrients (i.e., eutrophic conditions). *Eutrophication is defined as an increase in the rate of supply of organic matter to an ecosystem* [9]. An increase in the rate of supply of organic matter is either from external sources or from production within the system through biological processes stimulated by increased nutrients. Increased organic matter and, more specifically, nutrient inputs can lead to a variety of deleterious effects, including overgrowth of aquatic plants like dense nuisance and toxic algal blooms. Aquatic plants rapidly increase in abundance by uptake of excess nutrients, and through photosynthesis, converting this matter into biomass. When these plants die, this organic material sinks to bottom waters and is decomposed by microbes (e.g., bacteria), consuming oxygen in the process, which may lead to hypoxia, and in extreme cases, anoxia[10]. Thus, hypoxia and anoxia are key indicators of the health of an aquatic ecosystem. Yet, dissolved oxygen is only one of six symptoms used to track the effects of a more systemic problem – coastal eutrophication.

Fig. 2.5: Internal cycle of organic matter production in a wetland [11]

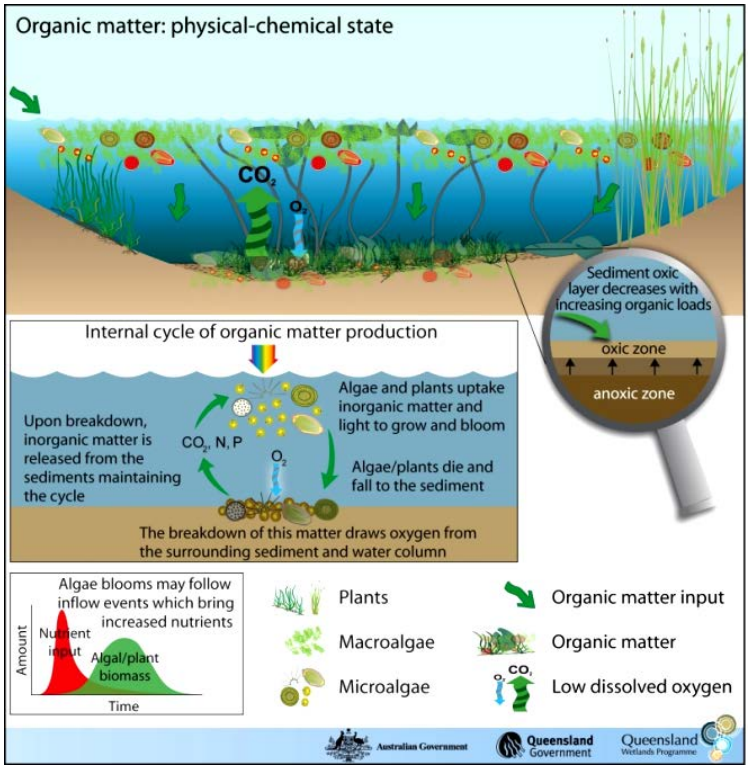
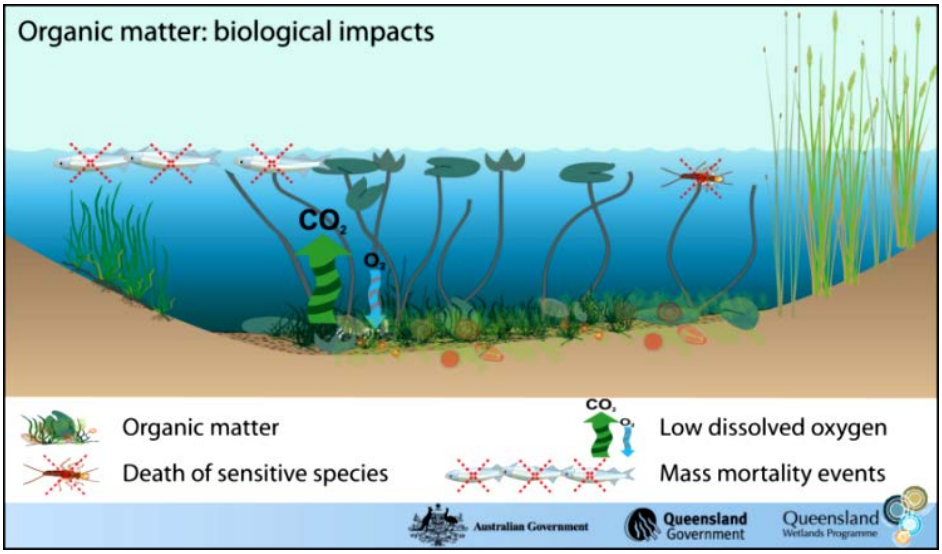


Fig. 2.6: Biological impacts and changes to the organic matter load entering a wetland [11]



Input of diffuse nutrient sources to coastal waters

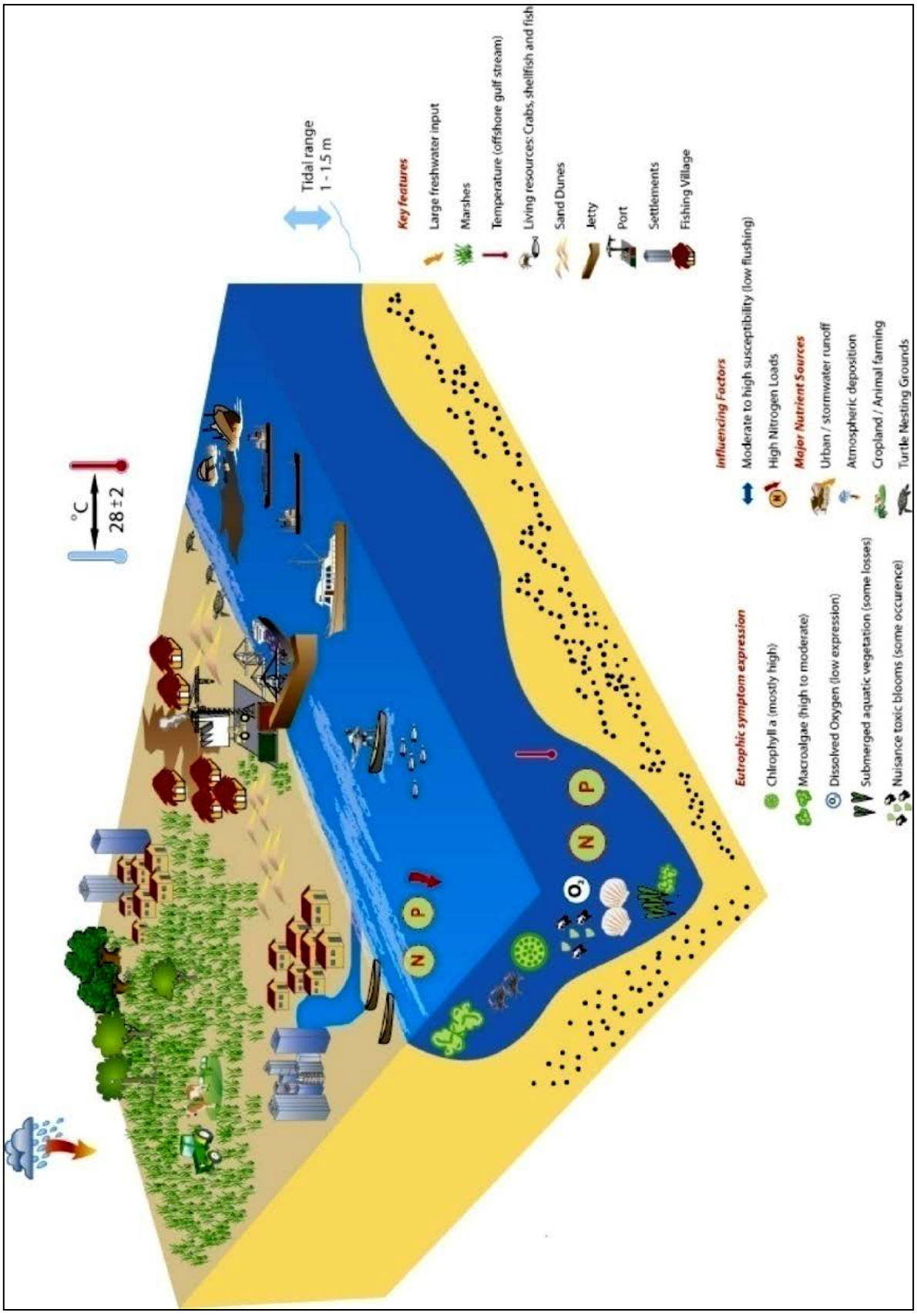
The largest human additions of nitrogen result from an increased use of inorganic fertilizers[12].For the past few decades, the Bay of Bengal has received relatively high levels of N fertilizer so that the ratio of N:P has been above the Redfield ratio[13].

2.2 Sea/ Marine-based Pollution

The sources of marine pollution from sea-based activities are related to fishing, recreational boating, marine transportation and offshore mineral exploration and production activities. Accidental oil spills have been frequently reported along oil transport routes or at the points of discharge and loading for oil carriers in the Bay of Bengal coast of India. Marine waters also receive wastes directly from offshore activities, such as ocean-based dumping (e.g., from ships and offshore oil and gas operations). Most pollution in India arises from land-based sources - industrial & domestic wastes and agricultural run-off (Table 2.1). However, shipping and associated ship-building, breaking and port activities are becoming increasingly significant considering the steep increase in the number of ports and harbours.

It is estimated that the Bay of Bengal receives ~400,000 tonnes of oil through i) oil spills, ii) crude oil residues and iii) wastewater effluents from refineries (which are land based)[14]. Although not reported extensively along the Indian coast of the Bay of Bengal, oil and lube spillage also occurs during refueling of vessels and cargo handling. In addition, there are innumerable mechanized trawlers and boats engaged in fishing in the Bay of Bengal. The operators of these vessels dump wastes, including burnt oil, into the water, because of their ignorance about its adverse effects on the marine environment.

Fig. 2.7: Conceptual diagram of major sea based activities in South Asia



Organo-tin antifouling compounds used for the hulls of ocean-going vessels, are especially toxic to marine molluscs and their larvae. Unlike copper antifouling compounds, organo-tin toxins become trapped in biological food chains and cause cumulative pollution in harbours and marinas. In consequence, organo-tin was banned by the IMO in 1998. Vessels also require regular painting and utilize a wide range of highly toxic paints, paint removers, solvents, degreasers, and other compounds [15].

Marine waters also receive wastes directly from offshore activities, such as ocean-based dumping (e.g., from ships and offshore oil and gas operations).

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1 GESAMP, 1986. ENVIRONMENTAL CAPACITY -An Approach to Marine Pollution Prevention. GESAMP Reports and Studies No. 30, http://www.fao.org/docrep/meeting/003/s0645e/s0645e00.htm#P177_12231

2 USEPA Glossary; http://cfpub.epa.gov/npdes/glossary.cfm?program_id=0#P

3 USEPA Polluted Runoff Background Paper; http://Www.Epa.Gov/OWOW/NPS/MMGI/Chapter1/Ch1-1.Html

4 Elrich de Sa, Present state of the coastal environment in India; http://www.teriin.org/teri-wr/coastin/papers/paper2.htm

5 U.S. Environmental Protection Agency (Preliminary Report). *National Coastal Condition Report.* EPA620-R-01-005. Washington, DC, August, 2001.

6 Rabalais, N.N., and S.W. Nixon. “Preface: Nutrient Over-enrichment of the Coastal Zone.” Estuaries 25, no. 4B (August 2002): 639.

7 India: Central Pollution Control Board Municipal sewage pollution along Indian coastal waters Central Pollution Control Board, Delhi, 2002

8 http://cpcbenvis.nic.in/newsletter/sewagepollution/ch3-0205.htm

9 Nixon, S.W., 1995, Coastal marine eutrophication--A Definition, social causes, and future concerns: Ophelia, v. 41, p. 199-219.

10 CENR. 2003. An Assessment of Coastal Hypoxia and Eutrophication in U.S. Waters. National Science and Technology Council Committee on Environment and Natural Resources, Washington, D.C.

11 Wetland Info; Environment and Resource Management; Government of Queensland, Australia [http://www.epa.qld.gov.au/wetlandinfo]

12 National Research Council. Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution. Washington, DC: National Academy Press, 2000.

13 Redfield ratio or Redfield stoichiometry is the molecular ratio of carbon, nitrogen and phosphorus in plankton. The stoichiometric ratio is C:N:P = 106:16:1

14 ESCAP. 1995a. State of the Environment in the Asia-Pacific, 1995, Bangkok

15 http://www.unescap.org/esd/environment/soe/2000/documents/CH05.PDF

CHAPTER 3: EXISTING WATER AND SEDIMENT QUALITY OBJECTIVES AND TARGETS

3.1. Introduction

Water is drawn from rivers in urban areas for domestic and industrial uses from rivers, lakes, and wells. About 80% of it comes out as wastewater and is disposed into receiving waters with little or no treatment and hence results in the pollution of surface and groundwater. Municipal sewage may be defined as “waste (mostly liquid) originating from a community; it may be composed of domestic wastewaters and/or industrial discharges”. It is a major source of water pollution in India, particularly in and around large urban centers. Out of about 38,000 million liters per day (MLD) of sewage generated, treatment capacity exists for only about 12,000 MLD. The existing treatment capacity is also plagued with operation and maintenance problems [1].

It is therefore essential for water quality monitoring to track the state of water pollution in the various water bodies especially rivers and ground water. This enables the setting in place of pollution control measures as well as evaluating their effectiveness. For this, the Central Pollution Control Board (CPCB) has established a network of water quality monitoring stations across the country. The water quality monitoring network is being operated under a three tier system as follows:

- Global Environmental Monitoring System (GEMS)
- Monitoring of Indian National Aquatic Resources System (MINARS)
- Yamuna Action Plan (YAP)

Currently, the network comprises of 1245 stations spread over the country in 27 States and 6 Union Territories with the sampling being done on a monthly or quarterly basis for surface water bodies, and on a half yearly basis for ground water. Out of 1245 stations 695 are on rivers, 86 on lakes, 19 on drains, 19 on canals, six tanks, 12 on creeks/ seawater, 26 ponds and 382 are groundwater stations [2].

3.2. Wastewater generation in coastal areas

A number of towns and cities are located in coastal areas and include such large urban conglomerations as Mumbai, Kolkata and Chennai and rapidly growing cities such as Kochi and Visakhapatnam. Apart from settlements, currently there are 13 Major and 187 Minor ports apart from numerous fishing harbours, power plants and industries. Many industrial clusters including the newly designated “Special Economic Zones” are located in coastal areas mainly for easy access to port facilities. In the past, the wastewater generated from settlements as well industries in coastal areas has been let into the sea under the assumption that dilution was the solution to pollution. A summary of details of a study conducted to understand the

generation of wastewater from Class I and Class II cities[3] located on the coast is given in Table 3.1. Class I (including metros) cities generate 6215.84 MLD of wastewater while Class II coastal cities generate 216.03 MLD of wastewater.

Table 3.1: Sewage generation in Class I cities in India

S. No.	Coastal State/UT	Coastal stretch (km)	Population	Number of Class I cities including metro cities	Number of Class II towns	Sewage generation in Class I cities in MLD	in %
1	Andhra Pradesh	974	5343940	13	5	402.76	**6.47**
2	Goa	104	295180	1	2	9.79	**0.15**
3	Gujarat	1663	5426029	9	4	107.55	**1.70**
4	Karnataka	300	701344	2	1		**---**
5	Kerala	560	4555591	9	11	764.14	**12.29**
6	Maharashtra	720	15790854	4	2	2549.86	**41.08**
7	Orissa	480	1338860	4	-	253.64	**4.08**
8	Tamil Nadu	1076	6847419	4	8	497.81	**8.00**
9	West Bengal	158	6959260	5	1	898.67	**14.54**
10	Andaman & Nicobar	1912	107200	1	-	12	**0.19**
11	Puducherry	45	333550	1	1	28.43	**0.45**
	TOTAL	**7992**	**476999227**	**53**	**35**	**6215.84**	

The total population of Class I cities (including metros) in coastal areas is 45 million and Class II towns is 2 million. The population of coastal metro cities alone is 31 million, which is 65% of total population of coastal Class I cities and Class II towns. The city of Mumbai (Maharashtra) on the west coast alone generates 2400 MLD i.e. 38 % of the wastewater generated. It also has treatment capacity of 2130 MLD (88% of the sewage generated). Similarly the coastal cities of Chennai (Tamil Nadu) and Kolkata on the east coast generate large amounts of wastewater. It is therefore clear that if the wastewater generated by the larger cities is treated properly before disposal, a large proportion of the coastal pollution due to municipal waste disposal would be addressed. Current treatment capacity is less than 50% of the wastewater generated. The wastewater from metros and Class I cities located on the coast is mostly disposed into creeks, canals or backwaters. It is estimated that 0.6 million tonnes of nitrogen and 0.1 million tonnes of phosphorus reach the coastal waters annually.

Designated "Best Use" of water

A "Water Quality Assessment Authority" (WQAA) was constituted under the Environment (Protection) Act, 1986, by the Indian government under the Chairmanship of the Secretary, Ministry of Environment and Forests, to standardize methods for water quality monitoring and to ensure quality of data generated. In May 2005, the WQAA decided that the data generated by the various agencies on water

quality should be used to formulate a water quality management plan to help in the restoration of water quality. The CPCB has prepared the Guidelines for water quality management plan [4]. The first step, according to the Guidelines is "Setting the Water Quality Goal". Figure 3.1 shows the flow chart for achieving this.

Fig 3.1: Setting the Water Quality Goal

The rationale behind the development of water quality parameters is defining the use to which a water body is subjected. Once the use is identified, the quality of water in such a waterbody is defined on the basis of pH, BOD, coliform count etc. The CPCB has identified 5 such "designated best uses" which are described in the Table 3.2 with drinking water quality being accorded highest quality.

Similarly, the wastewater let out through coastal outfalls also attracts water quality standards since water from the sea is also subject to various kinds of uses. Based on the "designated best use", primary water quality has been specified for five designated best uses as shown in Table 3.3.

Table 3.2: Classification of Water based on Designated Use (Freshwater)[5]

Designated Best Use	Class of Water	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	➢ Total Coliform: MPN/100ml shall be 50 or less ➢ pH between 6.5 and 8.5 ➢ Dissolved Oxygen 6mg/l or more ➢ Biochemical Oxygen Demand 5 days 20°C ≤2mg/l
Outdoor bathing (Organized)	B	➢ Total Coliform MPN/100ml shall be ≤500 ➢ pH between 6.5 and 8.5 ➢ Dissolved Oxygen ≥5mg/l or more ➢ Biochemical Oxygen Demand 5 days 20°C ≤3mg/l
Drinking water source after conventional treatment and disinfection	C	➢ Total Coliforms Organism MPN/100ml shall be ≤5000 ➢ pH between 6 to 9 ➢ Dissolved Oxygen ≥4mg/l ➢ Biochemical Oxygen Demand 5 days 20°C ≤3mg/
Propagation of Wild life and Fisheries	D	➢ pH between 6.5 to 8.5 ➢ Dissolved Oxygen ≥4mg/l

Designated Best Use	Class of Water	Criteria
		➢ Free Ammonia (as N) ≤1.2 mg/l
Irrigation, Industrial Cooling, Controlled Waste disposal	E	➢ pH between 6.0 to 8.5 ➢ Electrical Conductivity at 25°C micro mhos/cm Max. 2250 ➢ Sodium absorption Ratio Max. 26 ➢ Boron Max. 2mg/l
	Below E	Not meeting A,B,C,D,E criteria

Table 3.3: Standards of seawater quality[5]

	Class	"Designated Best Use" of sea water
Sea water	SW-I	Shell fishing, Mariculture and Ecologically Sensitive Zones
Sea water	SW-II	Bathing, Contact water sports and Commercial fishing
Sea water	SW-III	Industrial cooling, Recreation (non-contact) and Aesthetics
Sea water	SW-IV	Harbour
Sea water	SW-V	Navigational and Controlled waste disposal

All waterbodies in the country, including coastal waters, have been classified according to their designated use. This classification helps the water quality managers and planners to set water quality targets and identify needs and priorities for water quality restoration programmes for various water bodies in the country. It is based on these criteria that the various river conservation plans have been developed.

National River Conservation Plan

The National River Conservation Directorate (NRCD), functioning under the Ministry of Environment and Forests is engaged in implementing the River and Lake Action Plans under the National River Conservation Plan (NRCP) and National Lake Conservation Plan (NLCP) by providing financial assistance to the State Governments. The objective of National River Conservation Plan (NRCP) is to improve the water quality of the rivers, which are the major water sources in the country, through the implementation of pollution abatement works, to the level of designated best use. So far a total of 38 rivers have been covered under the programme. The activities carried out range from interception and diversion works to capture the raw sewage flowing into the river through open drains and diverting them for treatment, setting up sewage treatment plants for treating the diverted sewage to construction of low cost sanitation toilets to prevent open defecation on river banks and afforestation on the river banks [6].

National Ganga River Basin Authority (NGRBA)

It was established on 20th February 2009 as an empowered planning, financing, monitoring and coordinating authority for the conservation of Ganga River with a

holistic approach under the Environment (Protection) Act, 1986. Chaired by the Prime Minister and with the Chief Ministers of the five states through which the river flows (Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal), the authority is to take measures for effective abatement of pollution and conservation of the river Ganga in keeping with sustainable development needs. The Authority has decided that under the Mission Clean Ganga, by 2020, no untreated municipal sewage or industrial wastes will flow into the Ganga. In April 2011, the Cabinet Committee on Economic Affairs approved a Rs 7000-crore project for cleaning of River Ganga to be implemented by the NGRBA [7].

Other Action Plans for waterbodies:

Besides the river Ganga and its tributaries covered under the two Ganga Action Plans (GAP-I and GAP-II), the NRCD has taken up the pollution abatement projects of 14 other States covering 33 rivers and 71 towns.

The National Lake Conservation Plan (NLCP): This is similar to the river conservation plans in terms of working towards pollution abatement and so far a total of forty projects for conservation of 58 lakes have been sanctioned in 14 States. The work includes not only prevention of point source pollution but also in-situ measures such as de-silting and bio-remediation as well as catchment area treatment including shoreline development. The National Wetland Conservation Programme (NWCP) was initiated in 1987. A regulatory framework for conservation of wetlands has been prepared and put up on the website of the Ministry of Environment and Forests to obtain comments of all the concerned and State Governments. After incorporating all the relevant comments, the draft regulatory framework has been finalized and has been sent to Ministry of Law and Justice for vetting. Thereafter it will be notified under the Environment (Protection) Act 1986.

Coastal Ocean Monitoring and Prediction System

The Government of India, in the Ministry of Earth Sciences (formerly Ministry of Ocean Development) have been monitoring the levels of marine pollution at about 80 locations along the coastline of the country in a project called “Coastal Ocean Monitoring and Prediction System (COMAPS) [8].

The main objectives of the programme are as under:

1. To establish a knowledge base in the field of bio-geochemical parameters in the coastal shelf and open seas.
2. To operate appropriately structured information system for ready dissemination of various data sets to users in Government, industry, research and social institutions.

3. To conceptualize and implement R&D programmes that will continually update the knowledge and information bases and develop analytical frameworks for the quantification of transport rates and inputs of various chemical elements to different reservoirs and to the sea; characterizing the ecosystem and assessing its digestive capacity and in turn delineating policy options and facilitating decision processes in the wake of changing regimes.
4. To provide advisory and technical services to Government, industry and public institutions aimed at evolving pollution containment measures.
5. To detect radical changes in the bio-geochemical regimes of the marine system and to alert Government, public and social institutions of their implications.
6. To set standards for the measurement of various pollution parameters and to ensure compatibility between the data acquired and processed by various monitoring agencies through definition of equipment specifications, periodic intercalibration exercises, planned cross-checks and training programmes.

The programme has been operational from the year 1991-92 onwards. Data on nearly 25 environmental parameters including physical, chemical, biological and microbiological characteristics of water and sediment are collected with the help of R&D institutions in 0-10 km sector of these locations. The results obtained under the programme are periodically published in the Annual Report of the Ministry and also in the website http://www.dod.nic.in. Chapter 4 of this report contains more details about the programme and some of the results obtained so far.

1 CPCB, 2009. Status of water supply, wastewater generation and treatment in Class-I cities & Class-II towns of India. Control of Urban Pollution Series: CUPS/ 70 / 2009 – 10
2 CPCB: www.cpcb.nic.in
3 Class I cities – population > 1,00,000; Class II cities – population between 50,000 and 99,999
4 CPCB, 2008. Guidelines for Water Quality Management. www.cpcb.nic.in
5 Source: Website of the CPCB: http://www.cpcb.nic.in/Water_Quality_Criteria.php
6 MoEF Annual Report 2010
7 Centre approves Rs 7000 crore project to clean Ganga. Times of India, 28 April 2011.
8 DoD: http://dod.nic.in/comaps.htm

CHAPTER 4: THE NATIONAL PROGRAM COASTAL OCEAN MONITORING AND PREDICTION SYSTEM

4.1. Mapping hotspots along the coast

As mentioned in Chapter 2, a large number of cities and towns are located along the coast generating large quantities of wastewater. The current capacity of the treatment systems can treat barely half the quantity generated– a large volume of wastewater, treated, partially treated and untreated, reaches the coastal waters. Currently, the programme on Coastal Ocean Monitoring and Prediction Systems (COMAPS) is being operated by the Ministry of Earth Sciences. The main objective of the programme is to constantly assess the health of India marine environment and indicate areas that need immediate and long-term remedial action. Data on 25 environmental parameters (Table 4.1) including physical, chemical, biological and microbiological characteristics of water and sediment at about 76 locations are being collected with the help of seven RandD institutions in the 0-10 km sector of the coastline of the country, covering the maritime states and UTs. The major activity is to monitor the coastal water quality to understand the trend of marine pollutants load, whether increasing or decreasing, due to anthropogenic activities[1].

Table.4.1 List of Parameters measured by COMAPS Programme of MoES

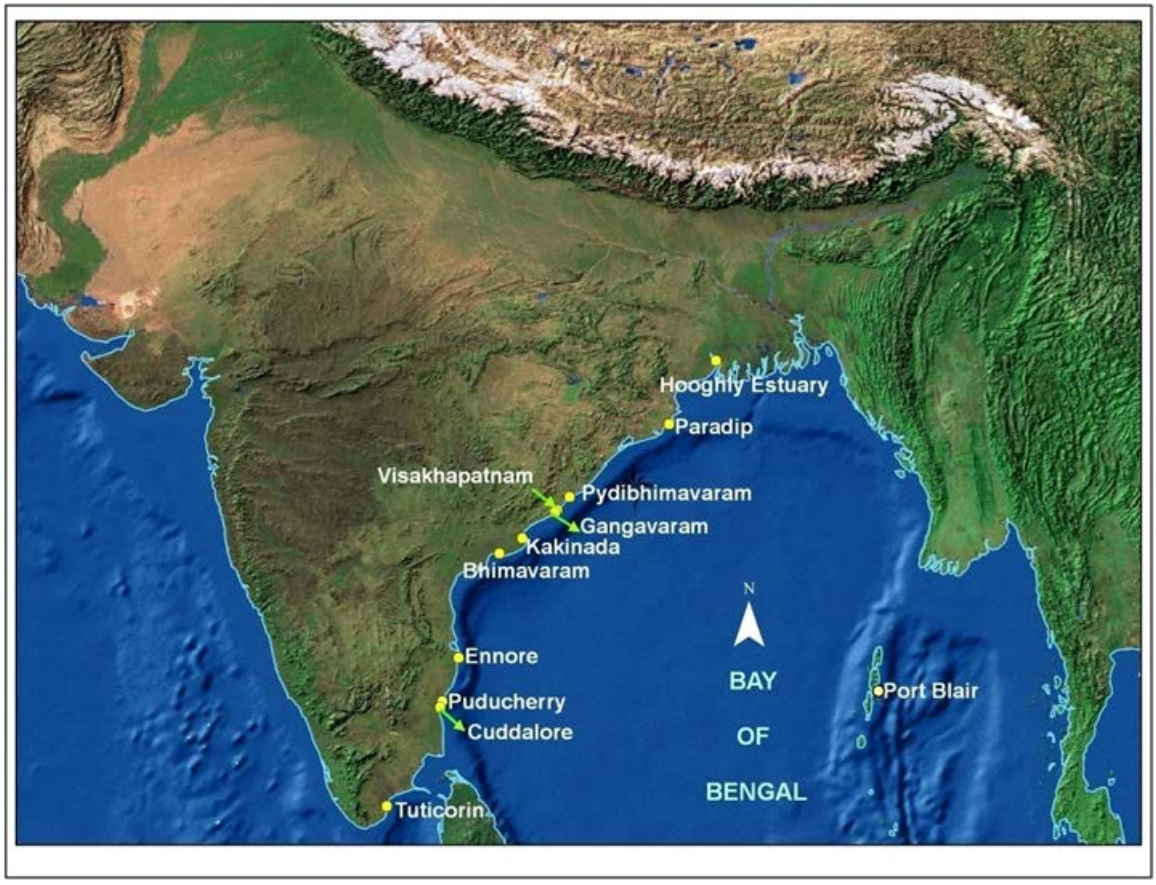
Parameters	Description	Units
	Water Quality	
TIDE	Low Tide / High Tide	LT/HT
ATEMP	Atmospheric temperature	°C
WTEMP	Water temperature	°C
SSC	Suspended sediment concentration	mg/l
pH		
Salinity		PSU
DO	Dissolved Oxygen	mg/l
BOD	Biochemical Oxygen Demend	mg/l
NO_2	Nitrite	µ mol/l
NO_3	Nitrate	µ mol/l
NH_4	Ammonia	µ mol/l
TN	Total Nitrogen	µ mol/l
IP	Inorganic Phosphate	µ mol/l
TP	Total phosphorus	µ mol/l
PHC	Petroleum hydrocarbons	µ g/l
	Sediments	
SAND	% composition	%
SILT	% composition	%
CLAY	% composition	%
ORGCARBON	Organic carbon	mg/g
Cd	Cadmium	µ g/g

Parameters	Description	Units
Pb	Lead	µ g/g
Hg	Mercury	µ g/g
	Biology	
PRIMPROD	Primary production	mgC/m^3/hr
CHLA	Chlorophyll a	mg/m^3
PHAE	Phaeopigments	mg/m^3
PHYTOTSP	Phytoplankton – Total number of species	nos
PHYPOP	Total number of phytoplankton	nos/l
PHYMAJSP	Major species	
ZOOBIO	Zooplankton biomass	ml/m^3
ZOOPOP	Zooplankton total population	nos/m^3
ZOOTOTGRP	Zooplankton total groups	nos
ZOOMAJGRP	Zooplankton major groups	
BENBIO	Benthos biomass	g/m^2
BENPOP	Benthos total population	nos/m^2
BENTOTGRP	Benthos total groups	nos
BENMAJGRP	Benthos major groups	
	Phytoplankton	
SPECIES	Phytoplankton species	
COUNTS	Phytoplankton population	nos/l
PERCOMP	Percent composition	%
TOTCOUNTS	Total population	nos/l
TOTSPS	Total number of species	
	Zooplankton	
SPECIES	Zooplankton species	
COUNTS	Zooplankton population	nos/m^3
PERCOMP	Percent composition	%
BIOMASS	Zooplankton biomass	ml/m^3
TOTCOUNTS	Total population	nos/m^3
TOTGRP	Total number of species	
	Benthos	
BENTYPE	Macrobenthos, Meiobenthos	
SPECIES	Benthos species	
COUNTS	Benthos population	nos/m^2 or 10cm^2
PERCOMP	Percent composition	%
TOTCOUNTS	Total population	nos/m^2 or 10cm^2
TOTGRP	Total number of species	
UNITS	Units	nos/m^2 or 10cm^2
	Microbiology	
BACTTYPE	Type of bacteria	
COUNTS	Number of colonies	nos
UNITS	Units	CFU/ml or CFU/g
	Types of Bacteria	
TVC	Total viable counts	
TC	Total coliforms	
FC	Faecal coliforms	
ECLO	Escherichia coli like organisms	
VLO	Vibrio like organisms	

Parameters	Description	Units
VPLO	Vibrio parahaemolyticus like organisms	
VCLO	Vibrio cholerae like organisms	
SLO	Salmonella like organisms	
SHLO	Shigella like organisms	
PKLO	Proteus klebsiella like organisms	
PALO	Pseudomonas aeruginosa like organisms	
SFLO	Streptococcus faecalis like organisms	

In order to create awareness among the public on the levels of marine pollution in the country, the Ministry of Earth Sciences has decided to publish the levels of pollution indicative parameters for the following locations at least every three months or as and when data are collected (East Coast commencing from 1st week of December 2006: Tuticorin, Cuddalore, Pondicherry, Ennore mouth, Bhimavaram, Kakinada, Gangavaram, Visakhapatnam, Paradip and Hooghly estuary[2].

Fig 4.1: Pollution Hotspots in the Bay of Bengal Coast



Latest information for each of these hot spots is summarized below[3]:

- **Tuticorin:** This port town generates an estimated sewage of 17.5 Million Litres per Day (MLD). There are no treatment facilities for the sewage and the entire raw sewage is disposed in canals and finally reaches the sea. In addition, there are a number of industries such as aquaculture ponds, chemicals and fertilizers industries, refinery and a thermal power plant. The total volume of waste discharge from these industries other than aquaculture is about 10,400 m^3/day.
- **Cuddalore:** The town's population generates about 13 MLD of sewage which is disposed of in an untreated form into the Ponnayar river which flows into the Bay of Bengal at Cuddalore. There is a major industrial complex which houses a variety of manufacturing industries which release approximately 7500 KLD of mostly treated wastewater into the backwaters that are connected to the sea.
- **Puducherry:** The 45 MLD waste water generated is discharged into the sea through backwaters and creeks in an untreated form. The total treated wastewater discharged from industries is about 7000 KLD.
- **Ennore (Chennai):** Situated north of Chennai city, this area has two power plants, a number of industries and a marine outfall discharging sewage. The total wastewater released by industries other than power plants is 28000m^3/day. The two power plants discharge about 100,000 m^3 of coolant water into the sea through the Ennore creek.
- **Bhimavaram:** Located about 20km inland, this area has a large number of aquaculture farms, industries and settlements. Discharge of untreated sewage by the civic bodies and effluents by industries is of concern. The wastewater from aquaculture farms contains high concentration of nutrients, toxic chemicals and antibiotics.
- **Kakinada:** Kakinada is important for its fertilizer plants, gas power plant, a deep water port and agriculture as well as aquaculture farms. South of Kakinada bay are the famous Coringa mangroves which are ecologically sensitive.
- **Visakhapatnam:** The coastal waters of Visakhapatnam receive a combination of untreated sewage and treated industrial waste. About 68 MLD of sewage is generated and about 55 MLD are discharged through the Mehalingatta, which drains into the Visakhapatnam harbour, the only natural harbour on the east coast.
- **Pydibhimavaram:** Located at about 60km from Visakhapatnam, this place has an Industrial Developed Area and also has developed as a hub for pharmaceutical industries. In order to keep track of water quality due to the industrialization of the area, collection of water quality data has been initiated in the sea off Pydibhimavaram
- **Paradip:** This port town generates about 6.6 MLD of sewage, discharged untreated into the coastal waters. There are two major industries, namely Paradip Phosphate and Oswal Chemicals and Fertilizers. Paradip Phosphate discharge treated

wastewater of 8900 m^3/day into the coastal waters through the creeks with the major pollutant being phosphate.

- **Hoogli Estuary:** The mouth of Hooghly river receives domestic sewage, mostly treated at Kolkata, and untreated sewage from a number of villages situated along the banks of the Hooghly. In addition, a number of industries discharge treated wastewater.

4.2. Time series analysis and significant findings

Time Series analysis: Time series analysis of a few of the parameters for selected sites has been carried out and is represented graphically in figures following this text. A trend line has been computed for each graph, providing an overall impression of the trend for each environmental parameter along the Bay of Bengal coast of India.

Fig. 4.2: Dissolved oxygen concentration in coastal waters of the selected locations of the Bay of Bengal

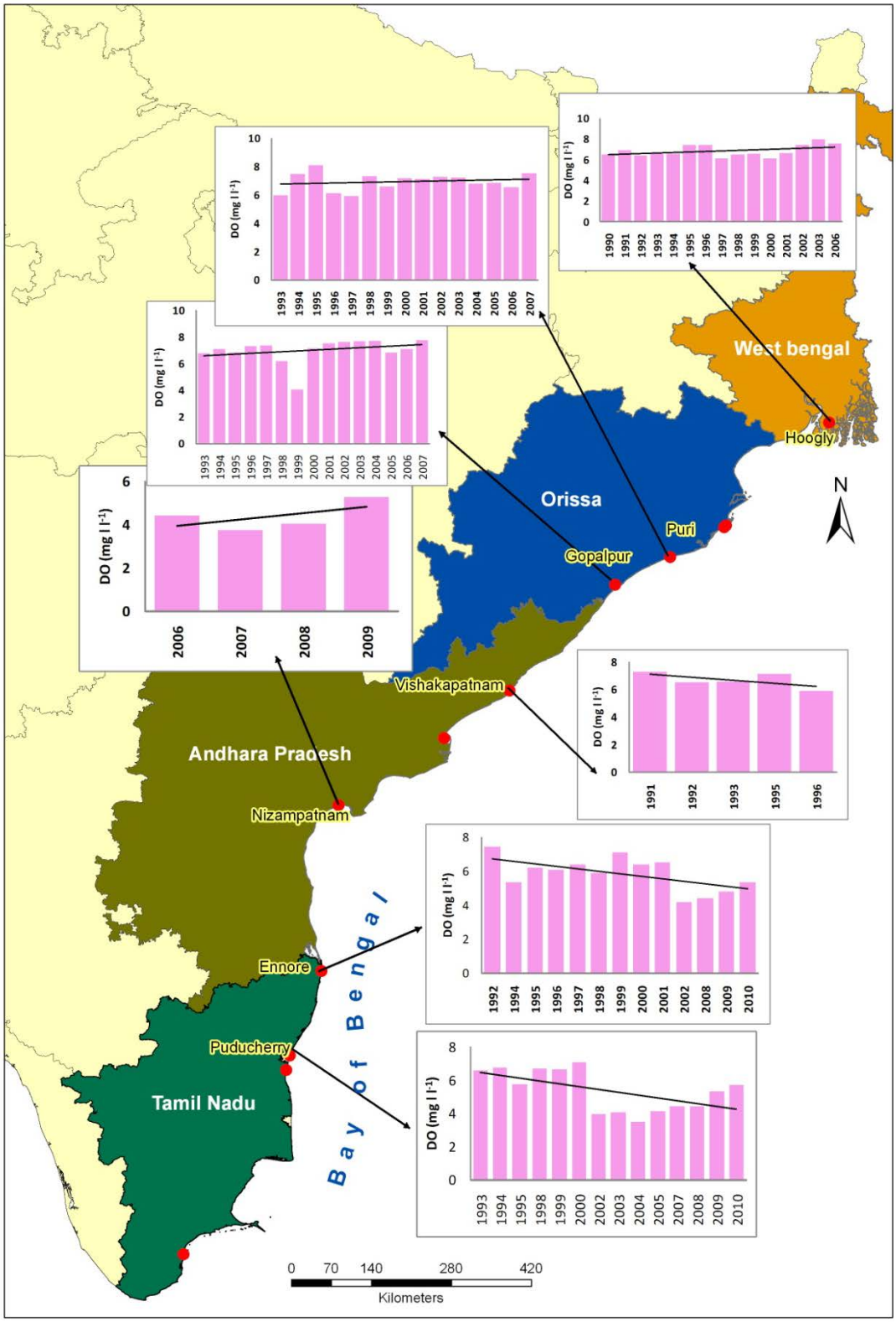


Fig 4.3(a): Dissolved inorganic nitrate concentration in coastal waters of the selected locations of the Bay of Bengal

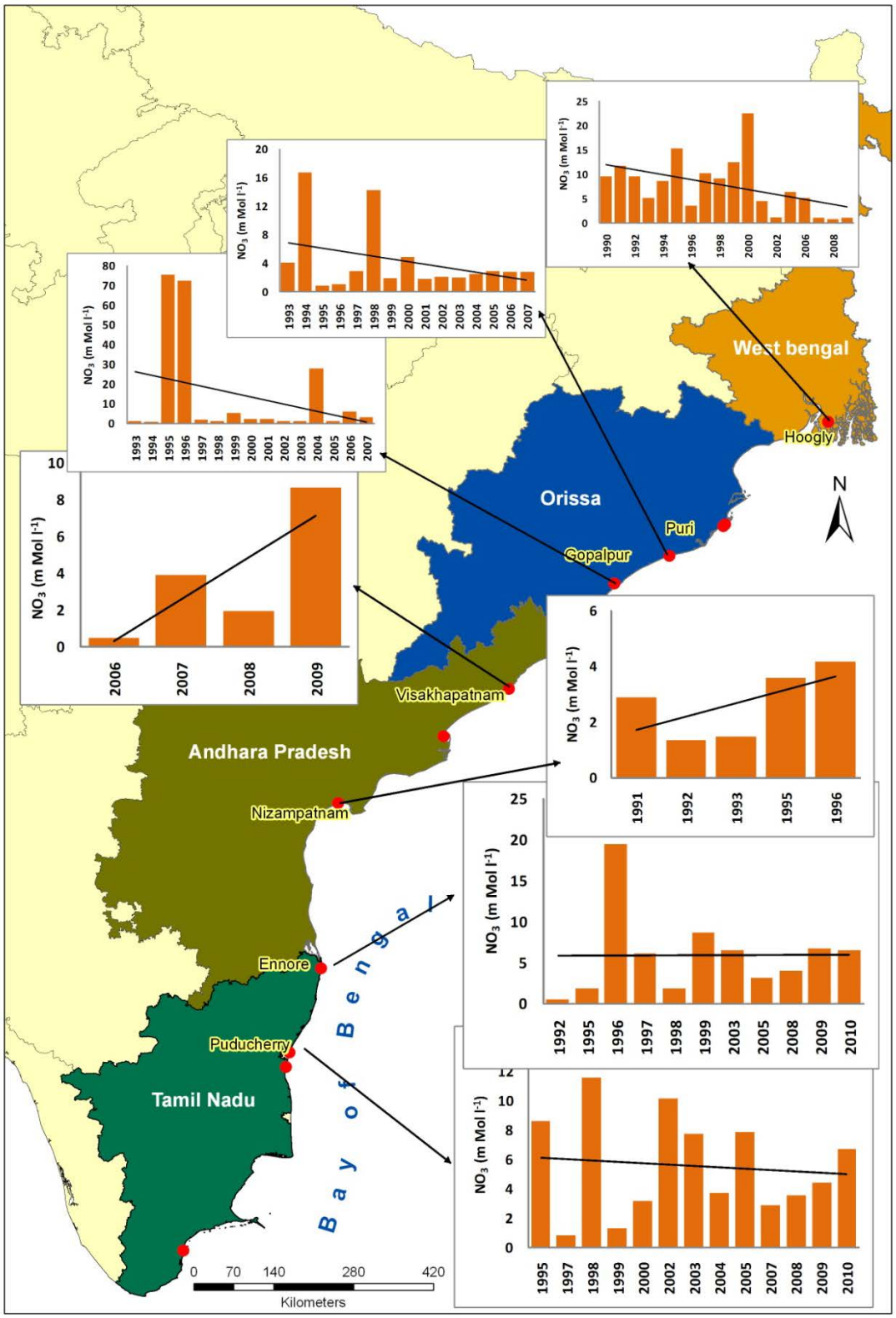


Fig 4.3(b): Trend in concentration of Ammonium in coastal waters of the selected locations of the Bay of Bengal

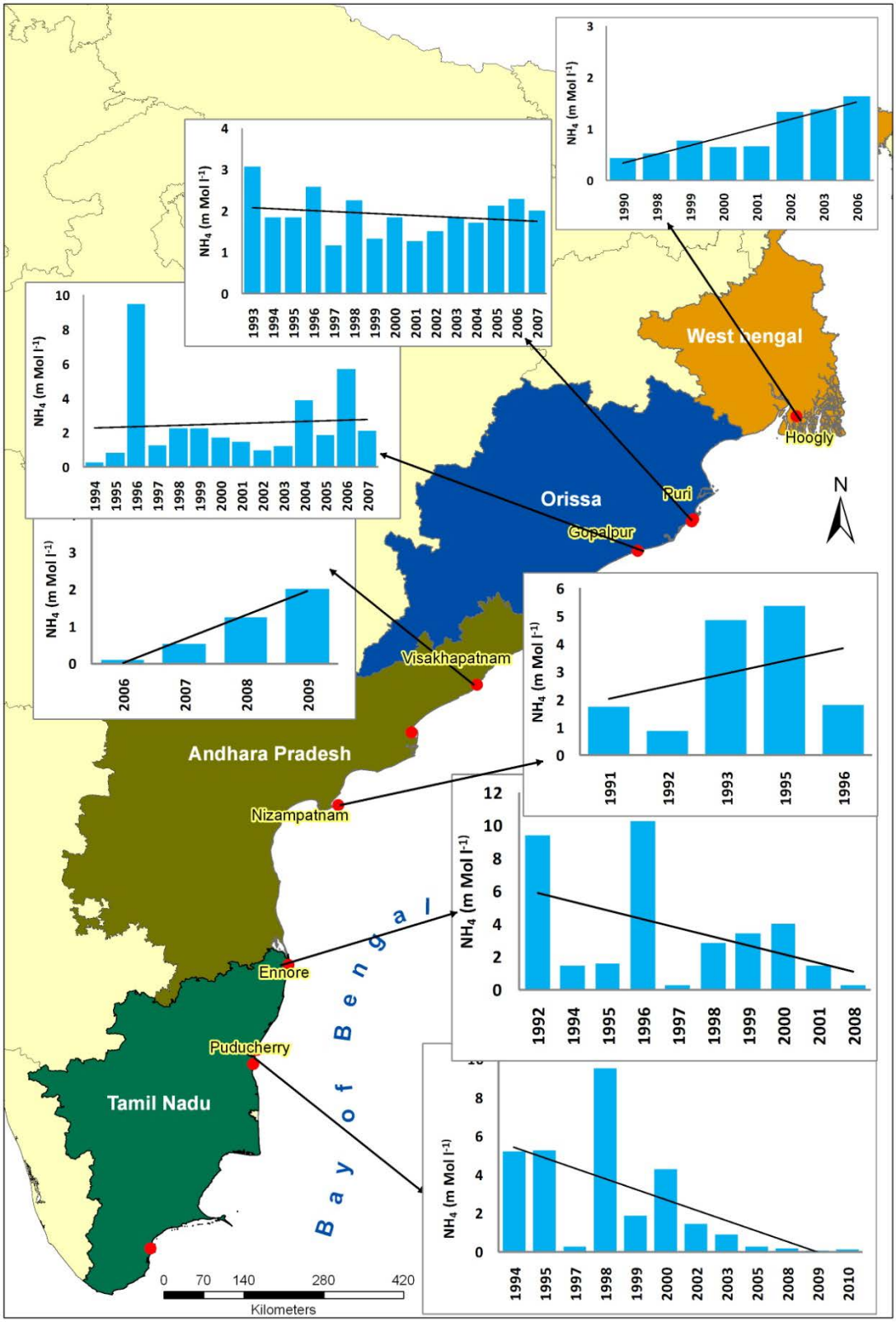


Fig 4.4: Total Dissolved Phosphorus concentration in coastal waters of the selected locations of the Bay of Bengal

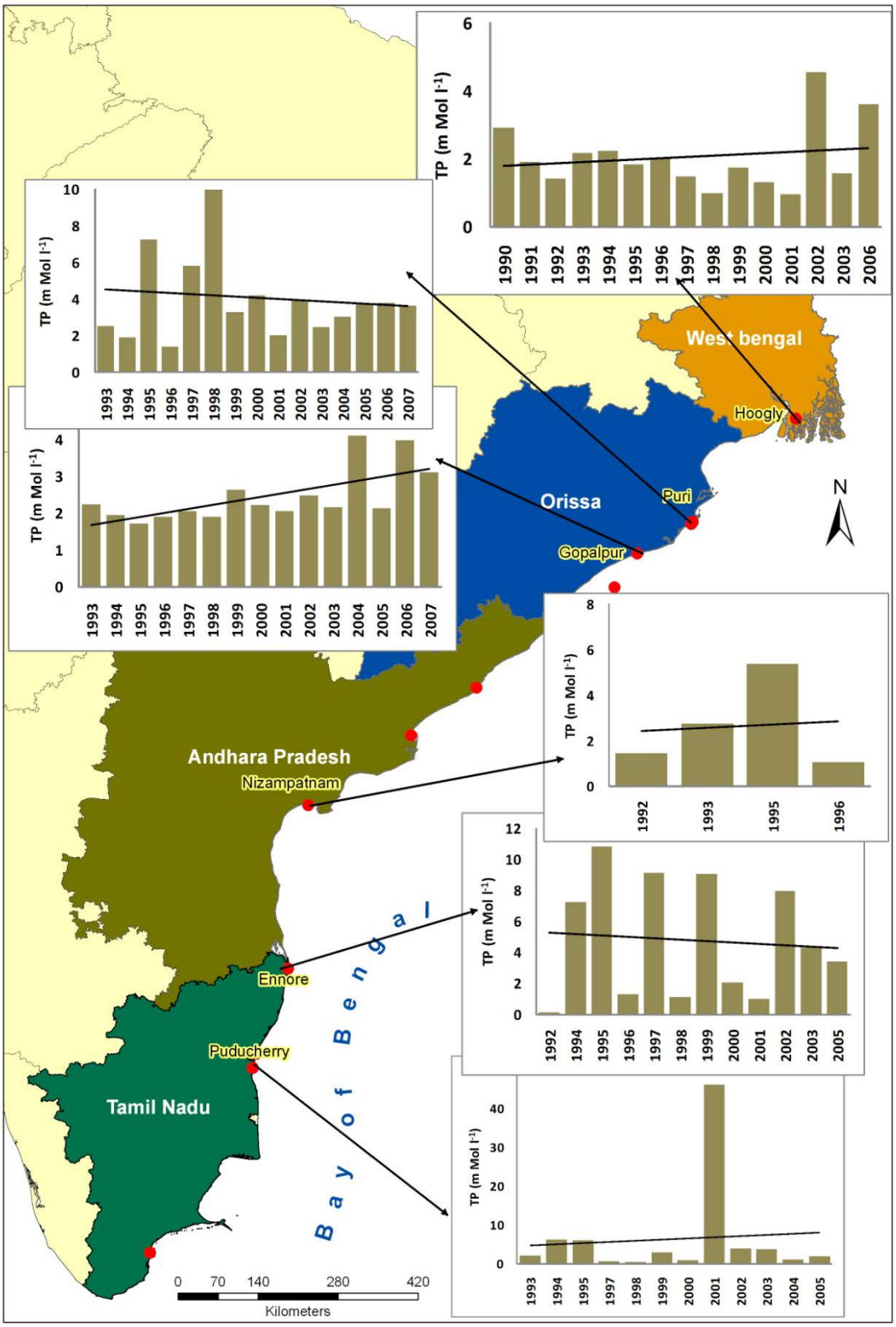


Fig 4.5: The Biological Oxygen Demand in coastal waters of the selected locations of the Bay of Bengal

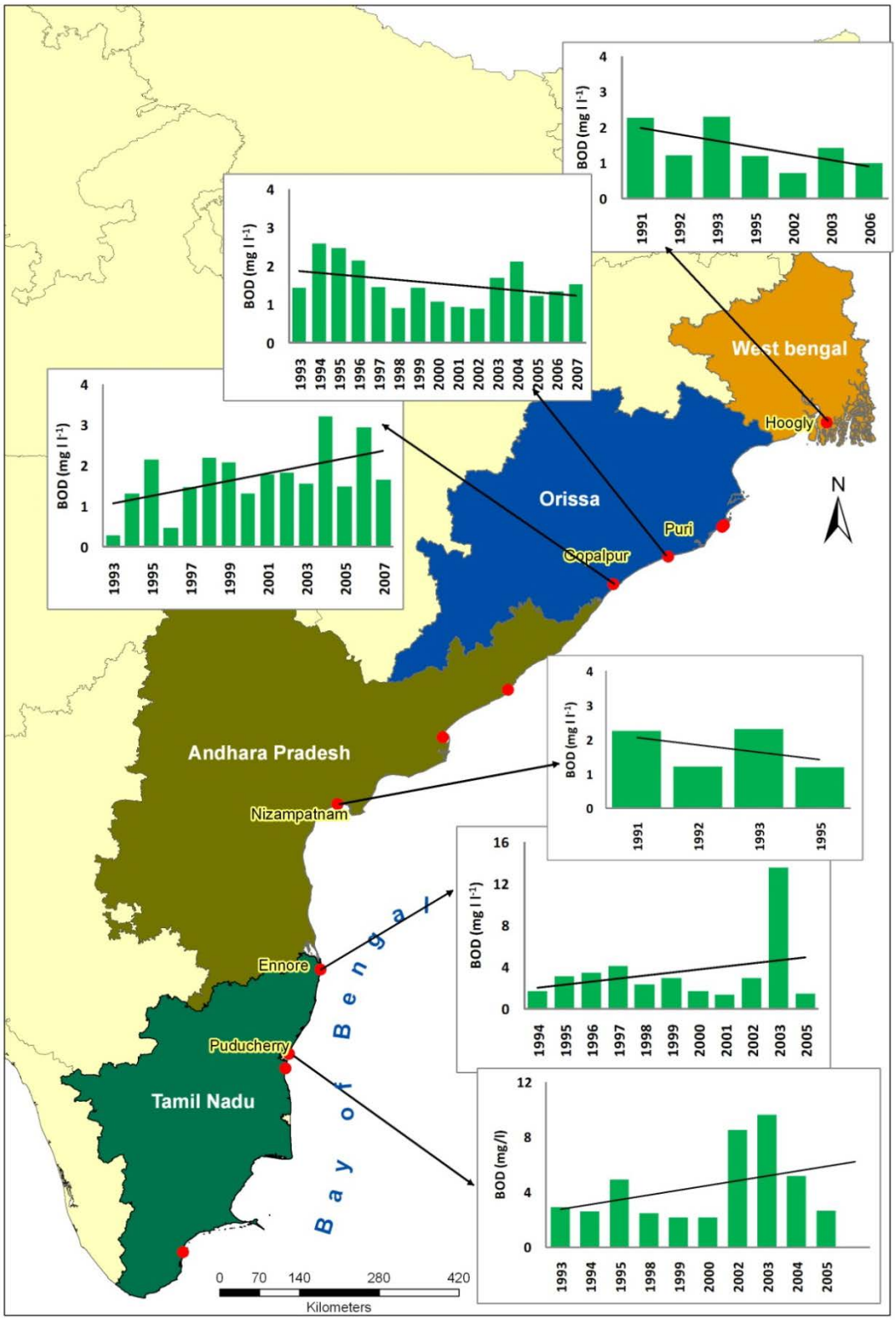


Fig 4.6: Trend in concentration of Total Coliform bacteria at selected locations along the Bay of Bengal coast

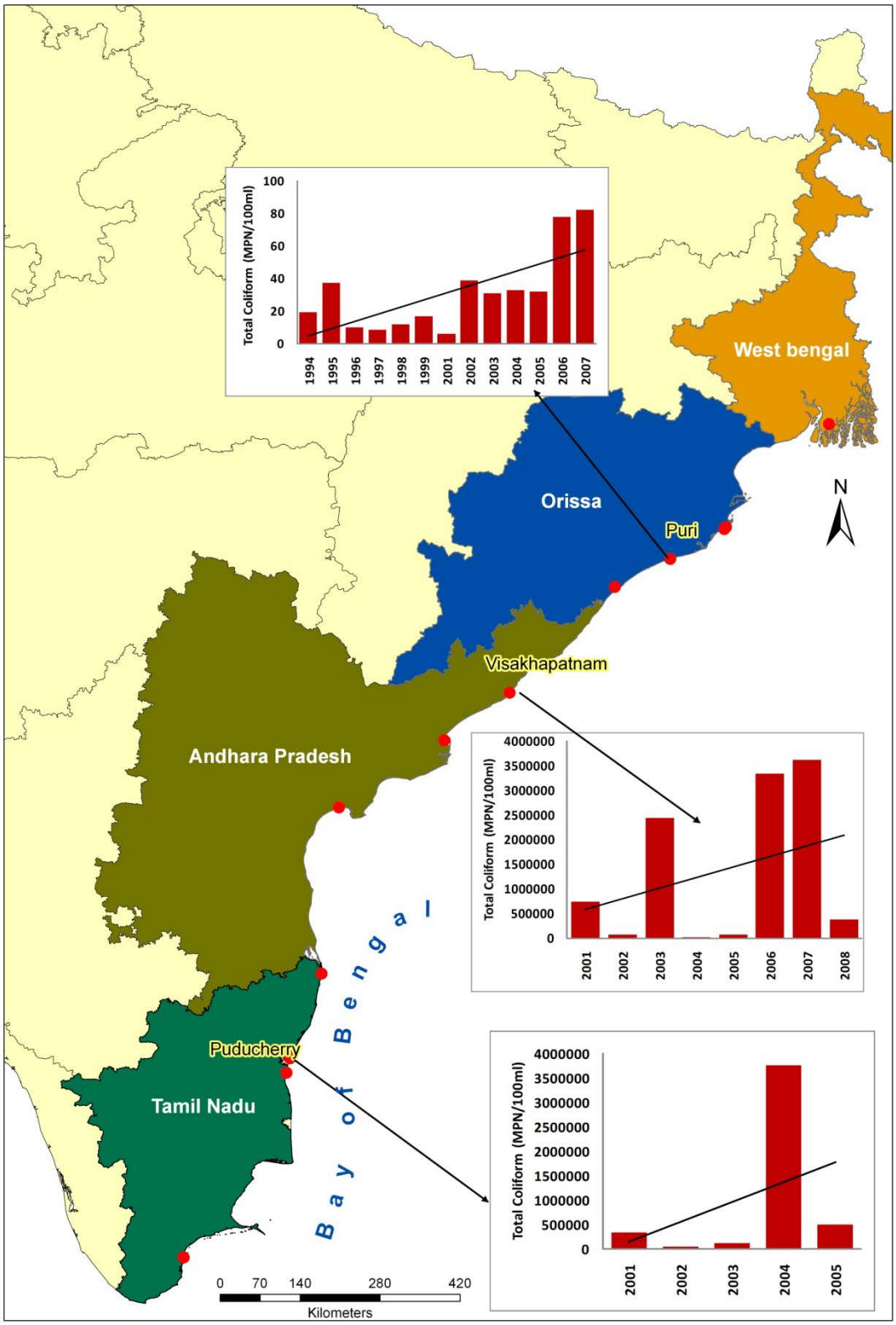
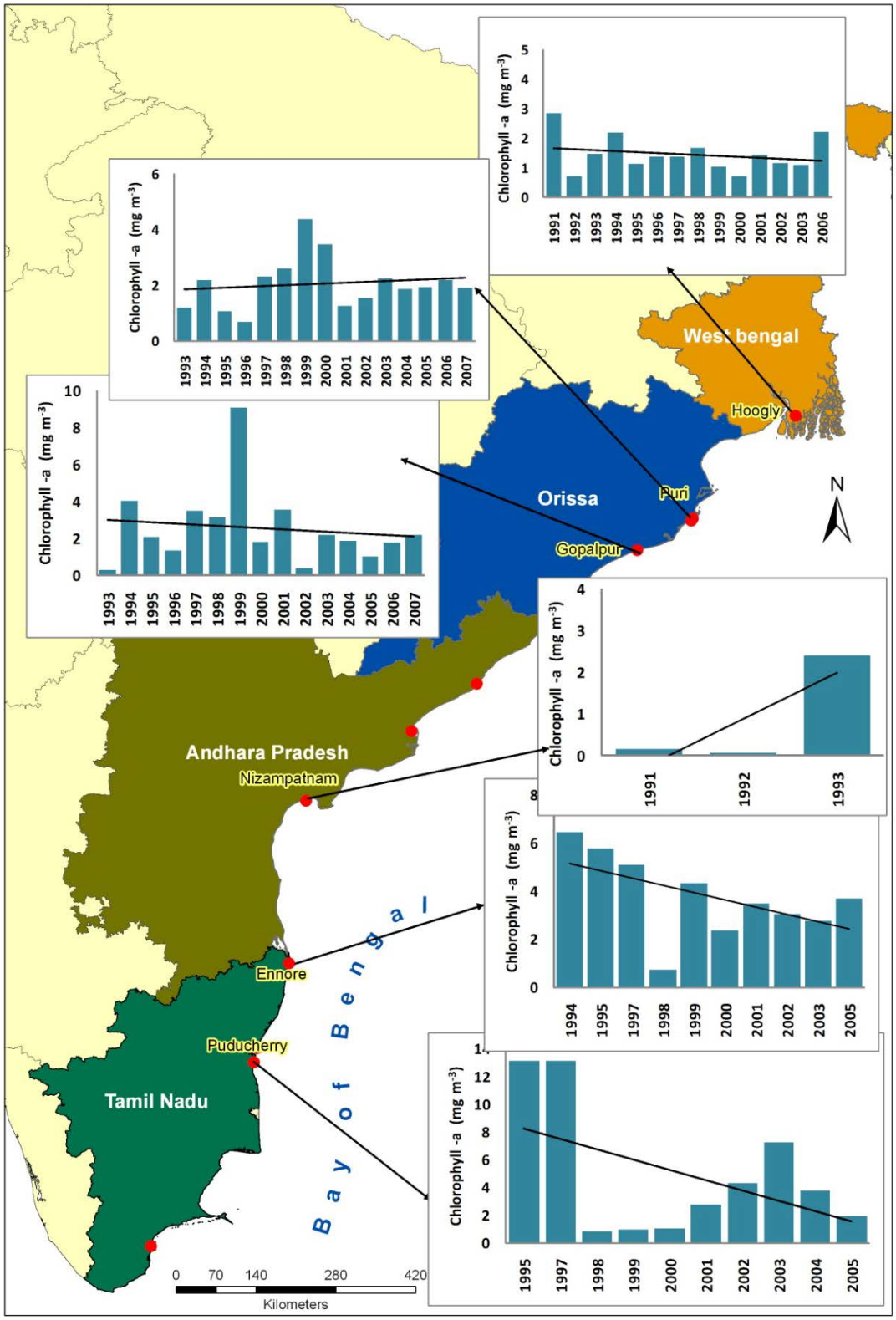


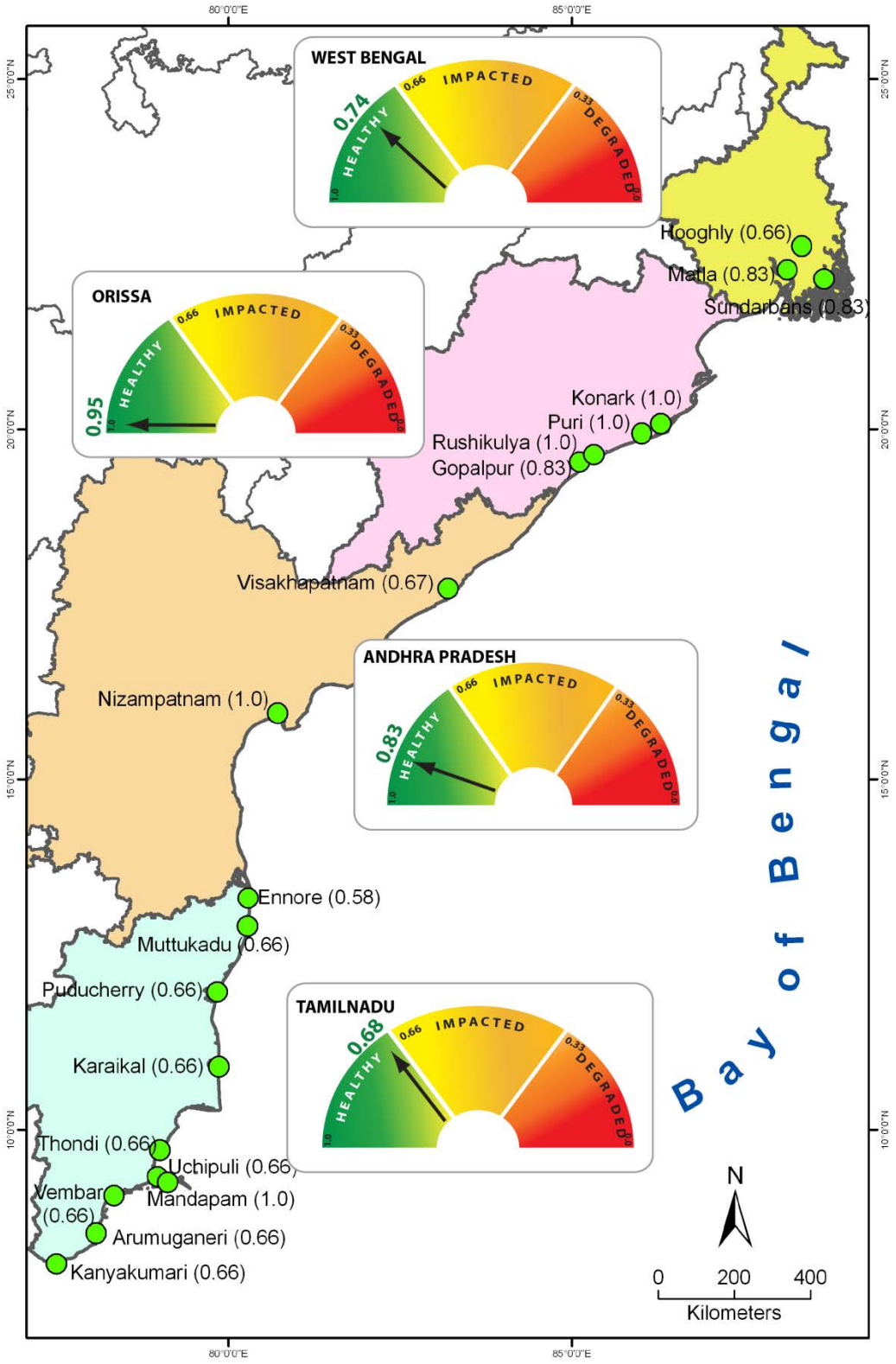
Fig 4.7: Trend in concentration of chlorophyll-*a* at selected locations along the coast of Bay of Bengal



A water quality index has been prepared averaging the area weighted scores for water clarity, dissolved oxygen, and chlorophyll a for each reporting region. The water quality index was calculated along the east coast from 1990-2009. The trends are represented in the images in Figure 4.8.

The overall water quality can be seen to have deteriorated over time considering the index runs from 0 (lowest) to 100 (highest) quality (Fig. 4.8).

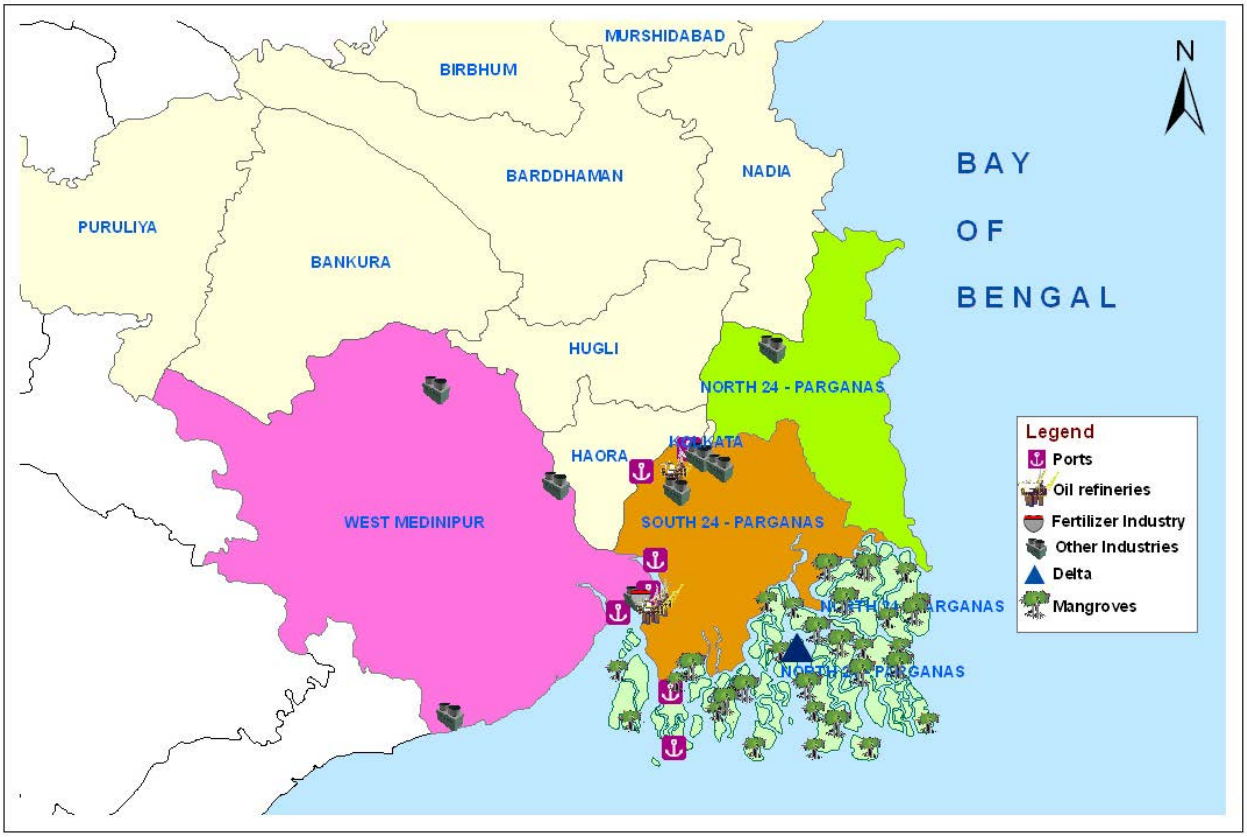
Fig 4.8: Water quality Index at selected locations along the Bay of Bengal Coast



Significant Findings: The states of West Bengal, Orissa, Andhra Pradesh and Tamil Nadu and the Union Territories of Puducherry and the Andaman and Nicobar Islands are located in the Bay of Bengal region. The following is a summary of the state-wise status of coastal water quality according to the Ministry of Earth Sciences:

West Bengal: Along the West Bengal coast, discharges from various types of industries are the major sources of pollution, besides agricultural runoff and port activities. Coastal waters of Sandheads, the Hooghly estuary and the Haldia Port were monitored during June – November 2009. Continued high DO levels (6 – 8 mg/l) and low biochemical oxygen demand (<3 mg/l) were observed indicating good water quality. However, at Hooghly estuary, high levels of total nitrogen (92µmol/l) and SSC (1055 mg/l) were observed. High levels of bacterial pathogens (FC: 1200 cfu/ml) was observed at Sandheads inshore waters indicating contamination due to domestic sewage.

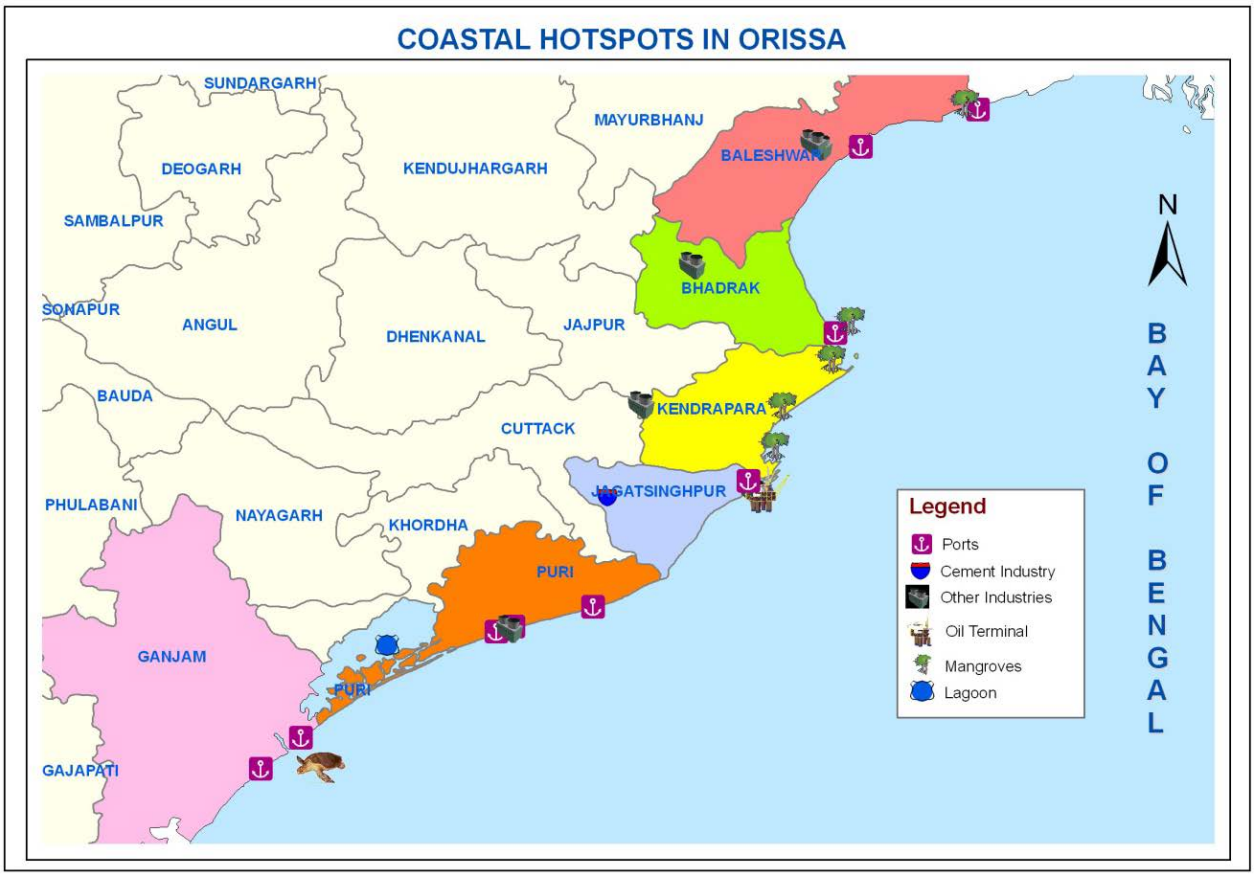
Fig 4.9: Coastal hotspots of West Bengal



Orissa: Along the Orissa coast, discharges from industries (mostly treated) and domestic sewage are the major sources of pollution besides untreated wastes from hatcheries, discharges from chromium and iron ore mining activities and agriculture.

During the year, coastal waters of Mahanadi, Paradip and Puri were monitored (Jun and Nov 2009). Coastal waters of Orissa are characterised by continued high DO levels (6 – 8 mg/l) and low biochemical oxygen demand (<3 mg/l) and low SSC (<15 mg/l) However, at Paradip, a moderate increase in levels of total phosphorous (23 µ mol/l) was observed indicating continued contamination from Paradip Phosphate factory. Significant decrease in levels of bacterial pathogens was observed at Paradip indicating moderate improvement in water quality. In general, the coastal water quality along Orissa coast has improved as compared to the previous year.

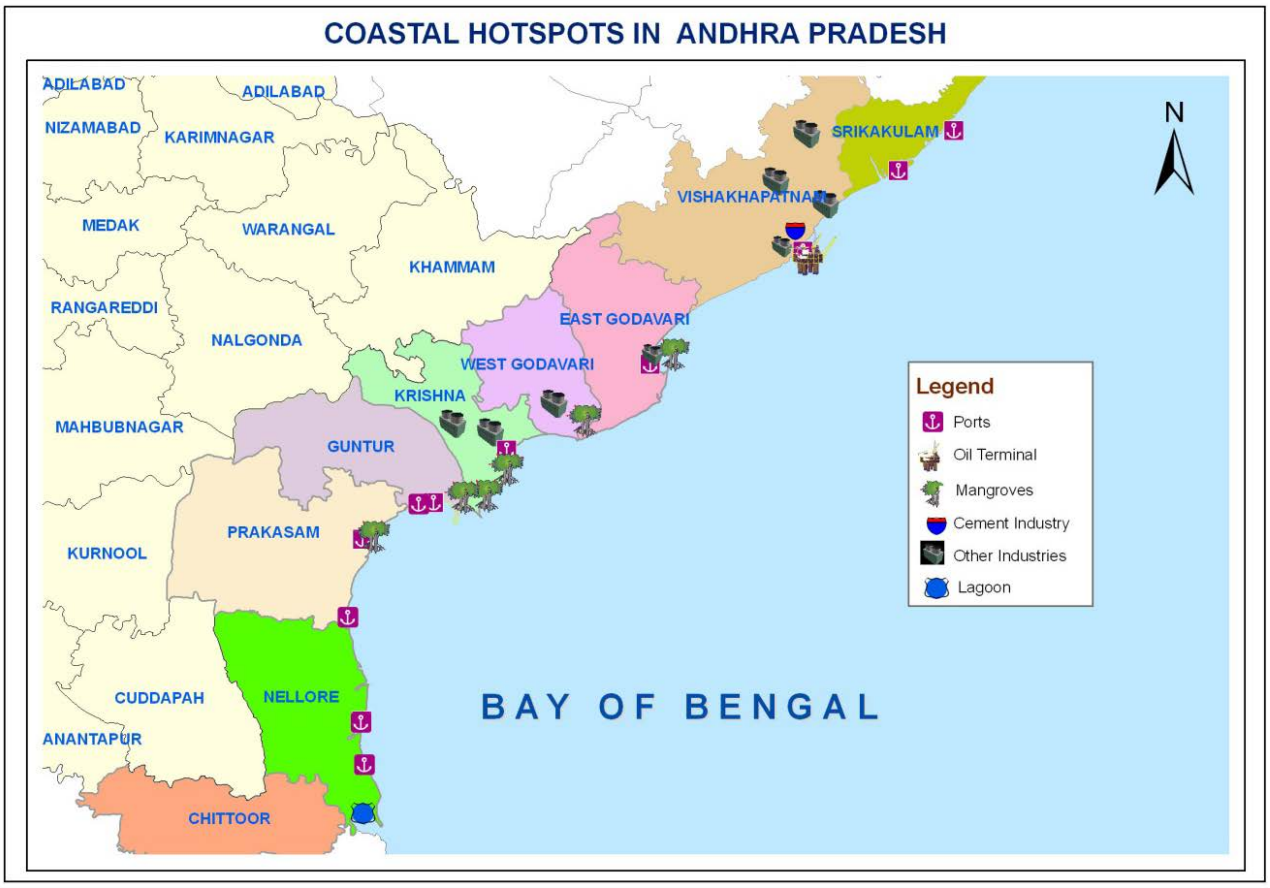
Fig 4.10: Coastal hotspots of Orissa



Andhra Pradesh: Along Andhra Pradesh coast, discharges from a variety of industries, agriculture and aquaculture are the major sources of pollution besides fishing activities and domestic sewage. During the year, monitoring was carried out at Visakhapatnam and Kakinada (Mar and Oct 2009) and along the coastal locations during December 2009. The results indicate high levels of nutrients in the Visakhapatnam harbour channels and Kakinada due to influence of domestic sewage, industrial effluents and

agricultural waste. Levels of nutrients were observed to be within ambient levels of coastal environment indicating that the coastal water quality along the Andhra Pradesh coast is fairly good.

Fig 4.11: Coastal hotspots of Andhra Pradesh



Tamil Nadu and Puducherry: In Tamil Nadu and Puducherry, effluents from industries and domestic sewage are the major sources of pollution besides harbour activities. Along Tamil Nadu coast, coastal waters of Ennore, Chennai Harbour, Cooum, Muttukadu, Puducherry, Cuddalore, Karaikal, Nagapattinam and Tuticorin were monitored (Jul, Oct and Dec 2009) and at other locations in Aug 2009. As compared to last year, there is a moderate decrease in levels of suspended solids concentration (from <190 mg/l - <100 mg/l). Dissolved oxygen level was well within normal range (3.5 – 6.8 mg/l) and biochemical oxygen demand (<5 mg/l) in all stations. Nutrient levels were also found to be at moderate level. However, a significant increase in pathogenic bacteria populations was observed at many shore locations.

Fig 4.12: Coastal hotspots of Tamil Nadu

Andaman and Nicobar Islands: Increase in shipping activities, disposal of untreated wastes and sewage are the major causes of pollution. Monitoring was carried out in seven places in and around Port Blair (Jun, Aug and Nov 2009) and Wandoor (Nov 2009). Levels of DO (3.5 – 7.4 mg/l), BOD (0.13 – 3.58 mg/l) and SSC (19 – 58 mg/l) and petroleum hydrocarbons (0 – 12 mg/l) indicate that coastal water quality has improved as compared to last year. Though very high levels of pathogenic bacteria were observed during Jun and Aug 2009, during Nov 2009 (post-monsoon), the levels were very low (<10 cfu/ml) indicating dilution of domestic wastes by monsoon rainfall. In general, the coastal water quality of Port Blair is observed to be improved as compared to last year.

4.3. Role of Ministries

4.3.1 Ministry of Environment and Forests

The primary role of the Ministry of Environment and Forests (MoEF) is the implementation of policies and programmes relating to the conservation of the country's natural resources including lakes and rivers, its biodiversity, forests and wildlife, ensuring the welfare of animals and prevention and abatement of pollution. In the course of its activities, the Ministry implements various laws of which the Environment (Protection) Act 1986, the Water (Prevention and Control of Pollution) Act, 1974 and the Water (Prevention and Control of Pollution) Cess Act, 1977 are directly relevant in the context of this report. The Ministry also administers a number of organizations including the Central Pollution Control Board.

4.3.2 Central Pollution Control Board (CPCB)

The **Central Pollution Control Board** (CPCB), a statutory organisation, was constituted in September, 1974 under the Water (Prevention and Control of Pollution) Act, 1974 and comes under the purview of the MoEF. The Board is responsible for planning and executing comprehensive nationwide programmes for the prevention and control of water and air pollution, for advising the Central Government on matters concerning prevention and control of water and air pollution and for coordinating activities of State Pollution Control Boards / Pollution Control Committees besides providing technical assistance and guidance to them. The CPCB has been playing a vital role in abatement and control of pollution in the country by generating environmental quality data, providing scientific information, rendering technical inputs for formulating national policies and programmes, training and development of manpower and organizing activities for promoting awareness at different levels of the Government and public at large. The Central Pollution Control Board also coordinates

enforcement and implementation of Rules framed under the Environmental (Protection) Act, 1986 with State Pollution Control Boards / Pollution Control Committees.

4.3.3 Ministry of Earth Sciences

The Ministry of Earth Sciences (MoES), formerly Ministry of Ocean Development, was established in the year 2006 by bringing the meteorological agencies and ocean development department under one umbrella considering the importance of coupled ocean-atmosphere processes for understanding the variability of weather, climate and hazards. The programmes of the ministry have been recast broadly into various categories, one of which is coastal marine ecology. Under this, water quality monitoring is carried out to assess the health of the coastal seas to gauge the status of pollution, to detect radical changes of pollutants and to alert government and public institutions, of their implications as part of the COMAPS programme described earlier.

4.3.4 National Laboratories

The following laboratories located in the Bay of Bengal coast have been involved in the COMAPS project.

Table 4.2: National Laboratories in the COMAPS Programme on the East Coast of India

State	National Laboratory	Sampling Sites
West Bengal	Central Pollution Control Board Zonal Office, Calcutta	Matla
	Institute of Minerals and Material Technology (IMMT	Hoogly
Orissa	Institute of Minerals and Material Technology (IMMT	Puri, Konarak, Rushikulya, Gopalpur, Paradip
Andhra Pradesh	NIO, Visakhapatnam	Goutami Godavari, Kakinada, Nizampatnam, Visakhapatnam, Gangavaram, Pydibhimavaram
	Centre of Advanced Studies in Marine Biology, Porto Novo (CASMB)	Gouthami Godavari, Visakhapatnam, Kakinada, Bhimavaram, Gangavaram
Tamil Nadu	Centre of Advanced Studies in Marine Biology, Porto Novo (CASMB)	Ennore, Arumuganeri, Cuddalore, Koodankulam, Mandapam, Muthukadu, Thondi, Tuticorin, Uchipuli, Vembar, Kanyakumari
	Central Electrochemical Research Institute -	Arumuganeri, Koodankulam, Pulicat, Thondi, Tuticorin, Kanyakumari

State	National Laboratory	Sampling Sites
	Tuticorin (CECRIT)	
	Central Electrochemical Research Institute - Madras (CECRIM)	Cuddalore, Mahabalipuram, Mandapam, Thondi,
Puducherry	Centre of Advanced Studies in Marine Biology, Porto Novo (CASMB)	Puducherry, Karaikal
	Central Electrochemical Research Institute - Madras (CECRIM)	Puducherry, Karaikal

The Institute for Ocean Management, Anna University Chennai has been involved in the creation of a GIS-based database and interpretation of the primary and secondary data. The Central Pollution Control Board (CPCB)'s component in the study is the assessment of the land based sources of pollution to the coastal waters so that appropriate measures can be taken to control the pollution.

1 Ministry of Earth Sciences, Annual Report 2009-10.
2 Integrated Coastal and Marine Area Management Project Directorate, Chennai. http://www.icmam.gov.in/comaps/index.html
3 http://www.icmam.gov.in/comaps/index.html

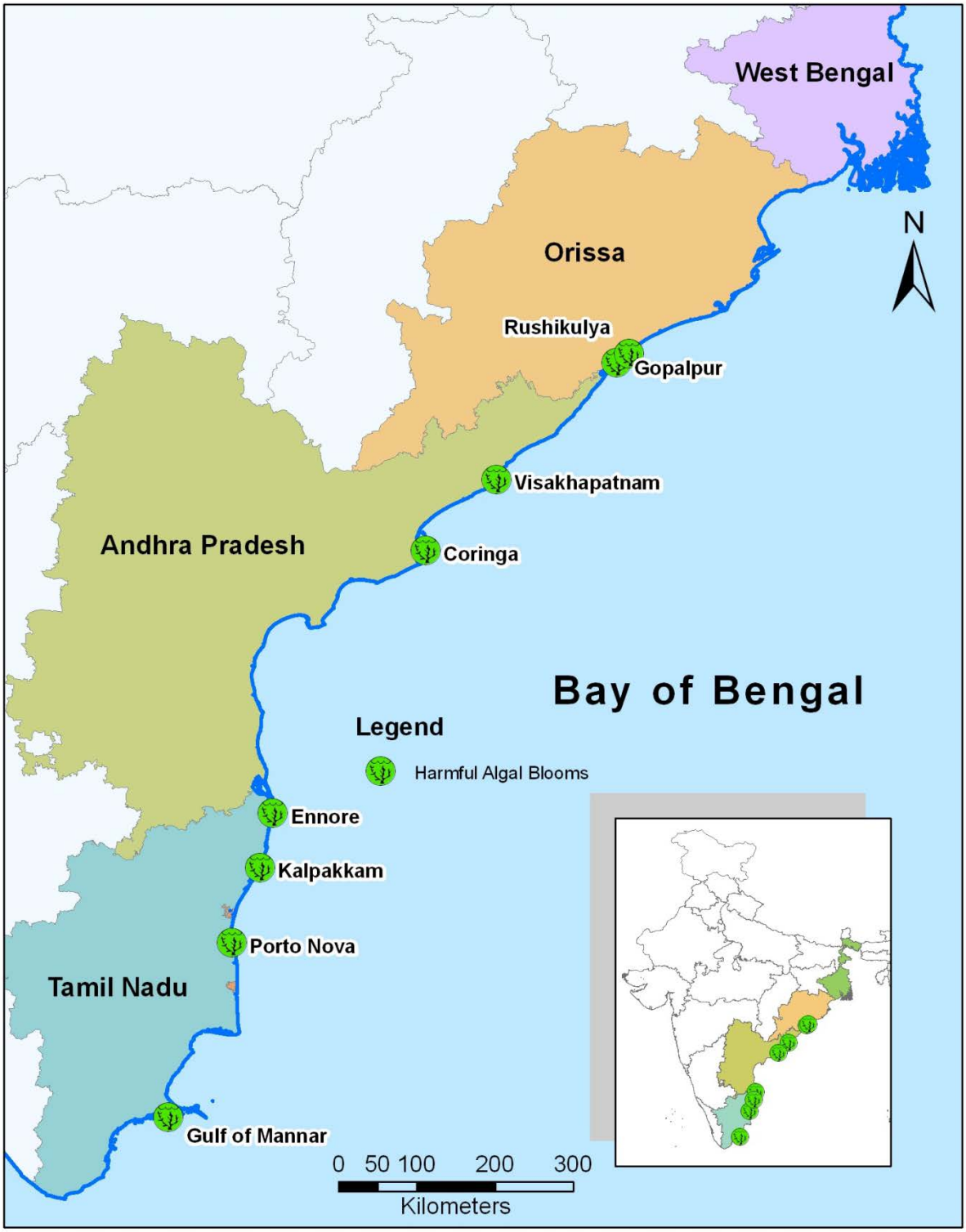
CHAPTER 5 PRESENT STATUS OF MARINE POLLUTION: CONTAMINANT LEVELS IN WATER, SEDIMENTS, FISH & OTHER BIOLOGICAL RESOURCES

5.1 Eutrophication and algal blooms in the coastal waters of Bay of Bengal

The Bay of Bengal (BOB) is a distinct tropical ecosystem situated in the monsoon belt and considered as class 1, highly productive ecosystem (>300 gC m^{-2} yr^{-1})[1]. High productivity is however more dominant in river mouths and estuaries. The large amounts of fresh water (ca.1.6×10^{12} m^3 yr^{-1}) discharged into the Bay give it an estuarine characteristic with low surface salinities over a large area. A wide range of variations in the nutrient concentrations have been observed and, although many rivers drain into the Bay of Bengal, the nitrate depleted surface waters in the northern part of bay suggest that there is no significant riverine input of nitrate and thus, nitrate is considered to be limiting the primary production in the Bay of Bengal[2]. Elevated concentrations of nutrients in some parts of coastal regions of Bay of Bengal have resulted due to the increased application of fertilizers, the discharge of industrial and domestic waste, animal production, the combustion of fossil fuels and nutrient mobilization due to land clearing. These additional nutrients stimulate algal growth and alter the balance between the production and decomposition of organic matter, leading to eutrophication in few areas of the Bay of Bengal[3].

Thirty two algal species have been found to contribute to the blooms in the Bay of Bengal. The algal biomass measured as chlorophyll a is higher in the Bay of Bengal (30–200 mg m^2) than in the Arabian Sea and also results in a high primary production[4]. In the east coast of India, phytoplankton blooms are common during February to May when the prevailing hydrobiological conditions are relatively stable. During spring inter monsoon, eddies and recirculation zones from the coastal regions of Bay of Bengal due to the Western Bay of Bengal Current (WBC) were found to enhance phytoplankton growth[5]. Blooms occurred usually just after the southwest to northeast monsoon transition during which the current direction changes from equator to the poles in the Bay of Bengal[6]. Some of the major incidences of algal blooms in different parts of Bay of Bengal (Fig. 5.1) are discussed in the following section, from north to south along the coastal states of India.

Fig 5.1: Distribution of Harmful algal blooms along the Bay of Bengal Coast



5.1.1 West Bengal

Occurrence of algal bloom in northern Sundarbans has been reported. The number of definable Bacillariophyceae species exceeded Dinophyceae taxa, and the total number of bloom-forming species declined from a maximum of ten in 2000 to a minimum of two in 2007. Blooms of the diatom *Coscinodiscus radiatus* were common in 2000 and 2007. In estuaries, phytoplankton blooms are linked to fluctuations in river flow, stratification of the water column, grazing pressure by zooplankton, nutrient dynamics, and light availability. Tidal cycles and the onset of the monsoon season also played important roles in diurnal and seasonal variability of phytoplankton. In terms of phytoplankton blooms, no individual species reached bloom levels during the monsoon period, using the criteria suggested by Badylak and Philips (2004)[7].

Outside of the monsoon season, the highest frequency of blooms was observed in 2000 Table 1. All of the blooms involved diatom species and many of the blooms involved larger-celled species, such as *Coscinodiscus eccentricus* and *Ditylum brightwelli*. Important smaller species (size<20 µm) included *Navicula rhombica* (15.8 µm), Leptocylindricus (18.8 µm), *Nitzschia seriata* (14.5 µm), *Thalassiosira decipiens* (small cell, 14.3 µm), *Nitzschia sigma* (12.3 µm), and *Skeletoema costatum* (11.8 µm).

Fig. 5.2: Eutrophication status of Haldia coast, West Bengal based on ASSETS Eutrophication Assessment

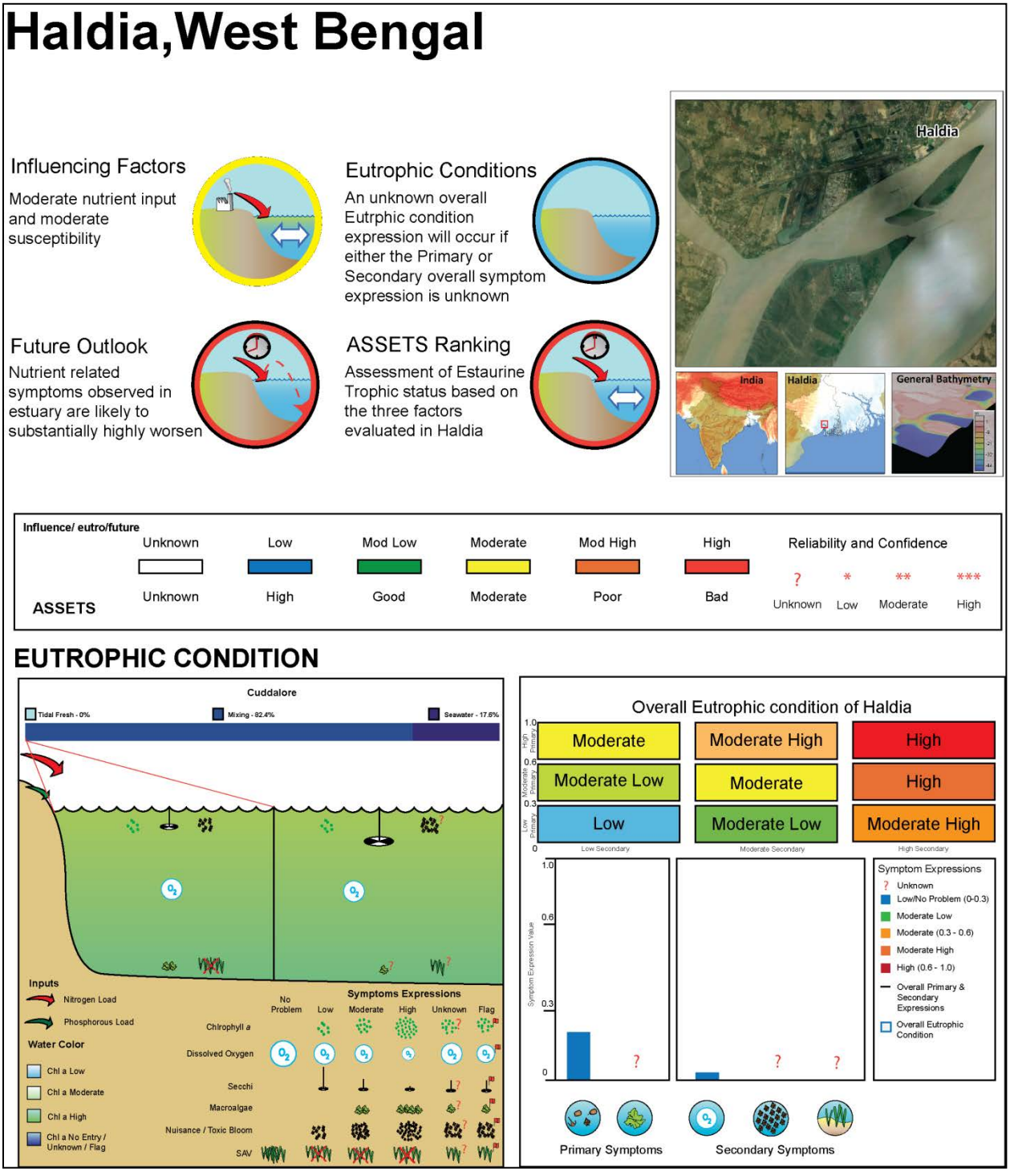


Fig. 5.3: Eutrophication status of Hooghly estuary, West Bengal based on ASSETS Eutrophication Assessment

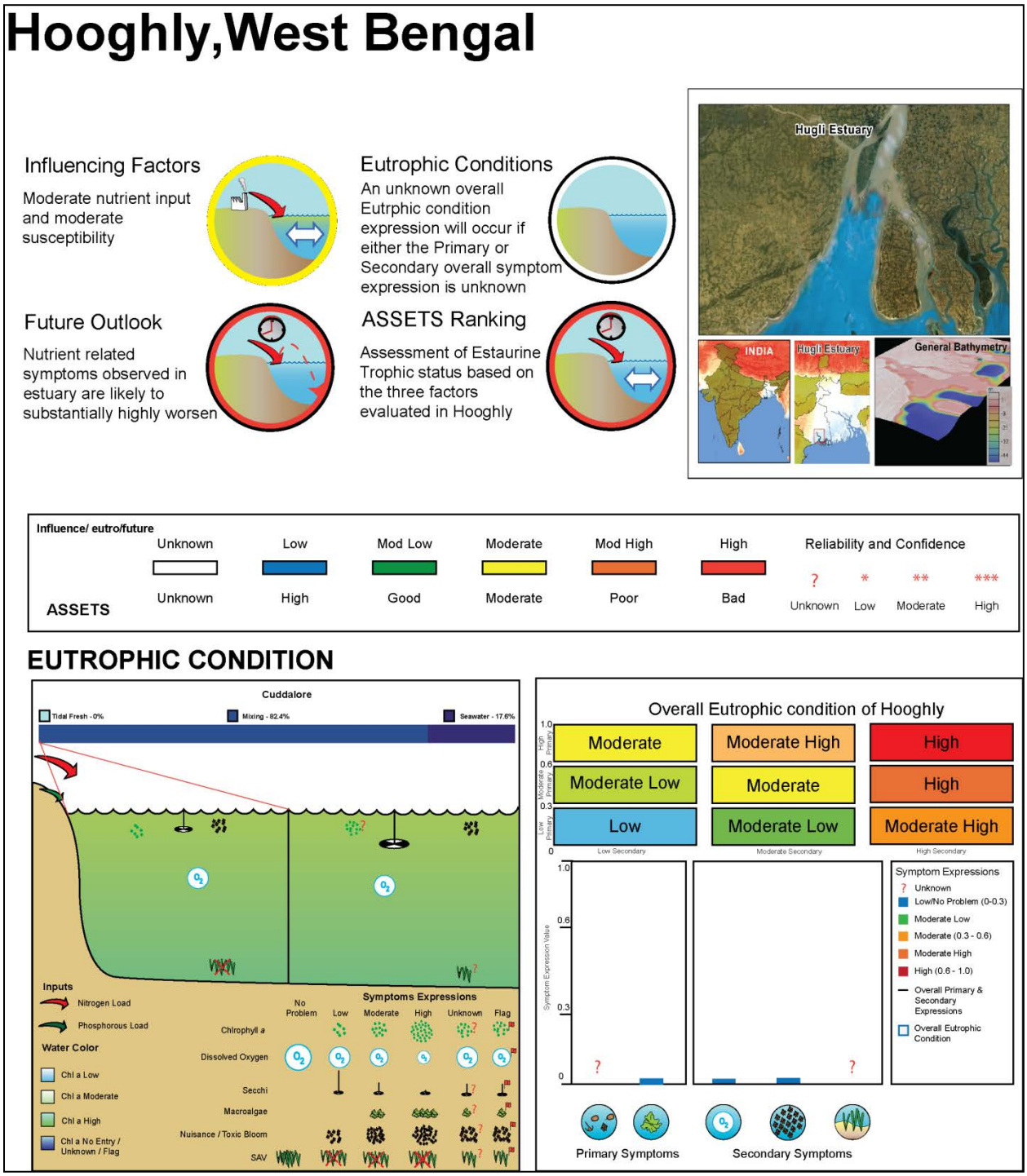
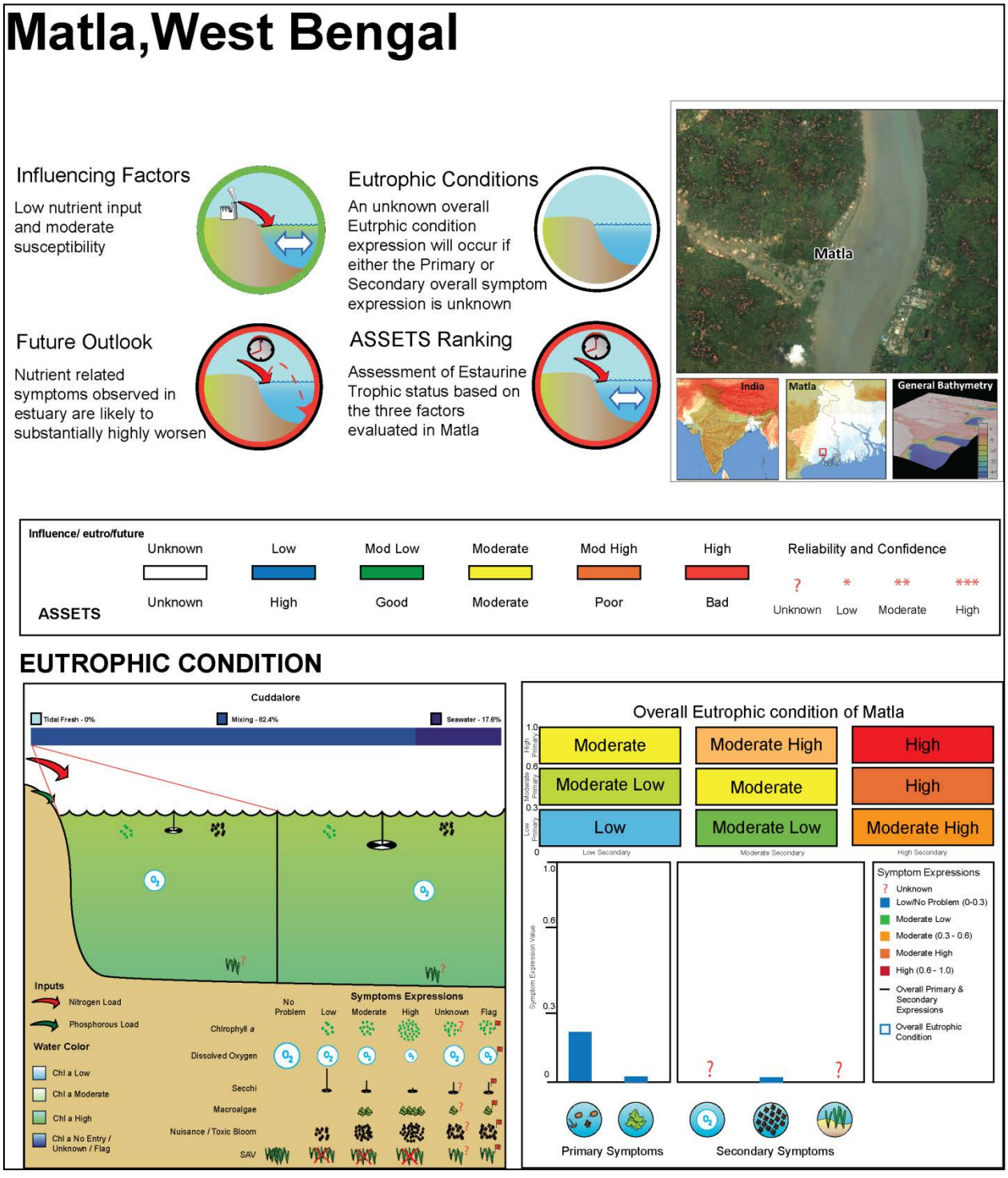


Fig. 5.4: Eutrophication status of Matla, West Bengal based on ASSETS Eutrophication Assessment



5.1.2 Orissa (north-western Bay of Bengal)

Algal blooms off the coast of Orissa occur occasionally, mainly caused by diatom genera such as *Asterionella, Chaetoceras* and *Skeletonema.* Occurrence of mono-species bloom of the diatom, *Asterionella glacialis* (Castracane) in the coastal waters of Gopalpur Sea was observed during April 2004. The stable hydrographic conditions coupled with increased nutrient concentrations are believed to have triggered the blooming of this diatom species. Termination of bloom occurred with the depletion of nitrate and silicate in the medium water. Phytoplankton community structure in terms of their species diversity, species richness and evenness showed distinct variations during the pre-bloom, bloom and post-bloom periods[8]. There were several instances of phytoplankton blooms in the coastal waters off southern Orissa. A study observed a prominent discolouration of the surface water in coastal waters off the Rushikulya River mouth during April 2005[9]. The bloom, caused by *Noctiluca scintillans* was dense and created red-coloured patches near the sea surface, covering a wide area of approximately 16 km^2.

Fig 5.5: Eutrophication status of Gopalpur coast, Orissa based on ASSETS Eutrophication Assessment

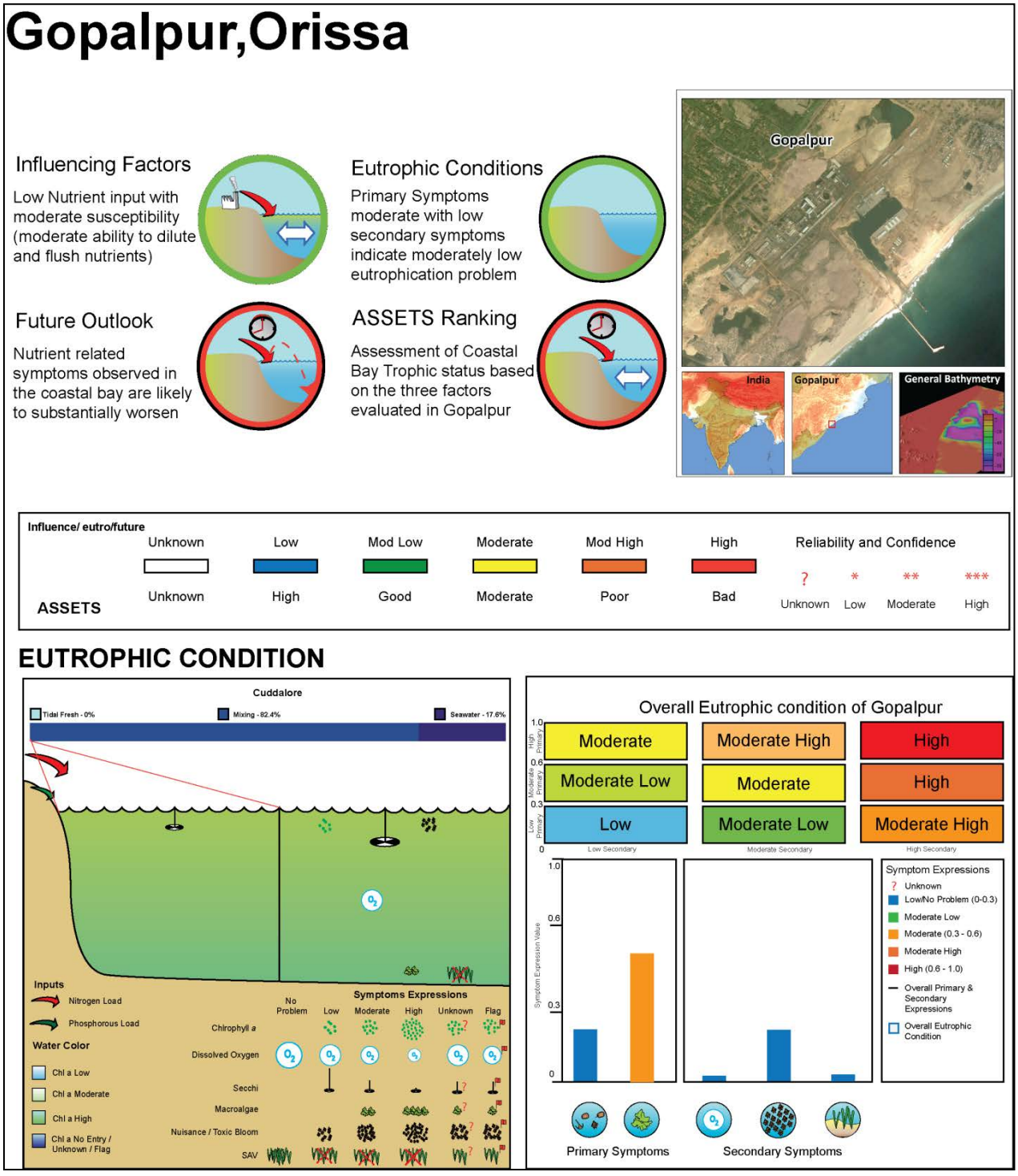


Fig 5.6: Eutrophication status of Konark coast, Orissa based on ASSETS Eutrophication Assessment

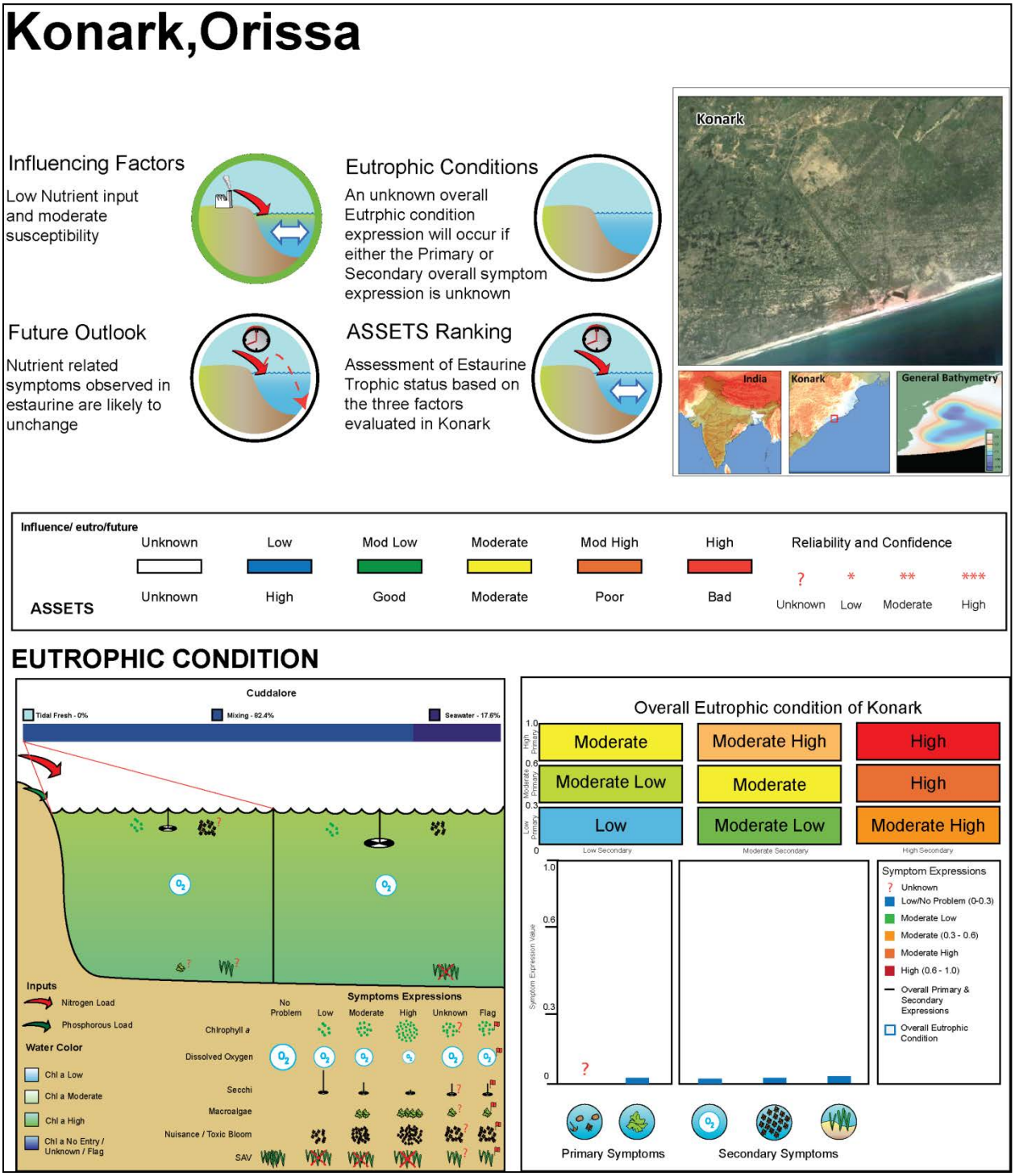


Fig 5.7: Eutrophication status of Mahanadi estuary coast, Orissa based on ASSETS Eutrophication Assessment

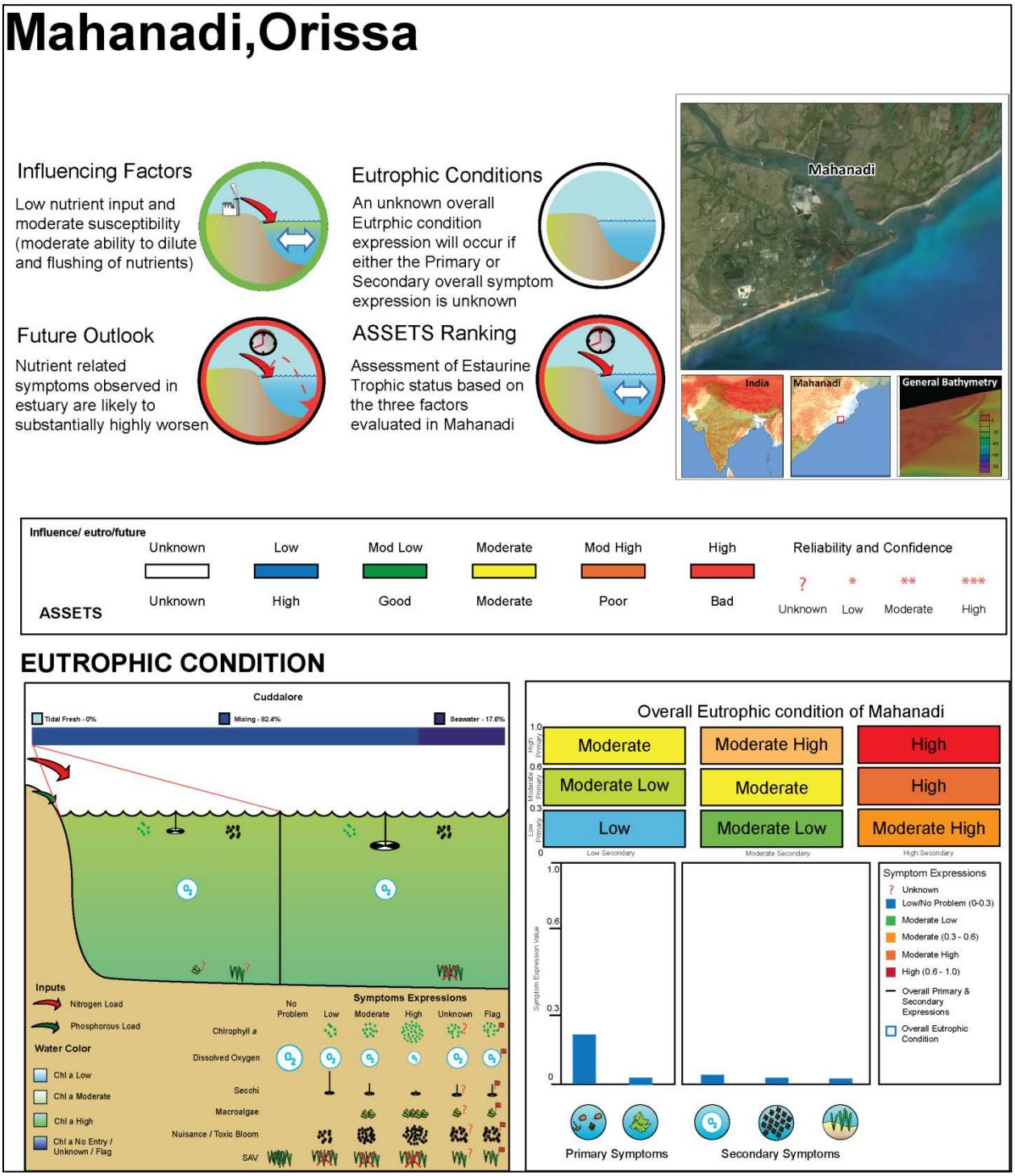


Fig 5.8: Eutrophication status of Paradip coast, Orissa based on ASSETS Eutrophication Assessment

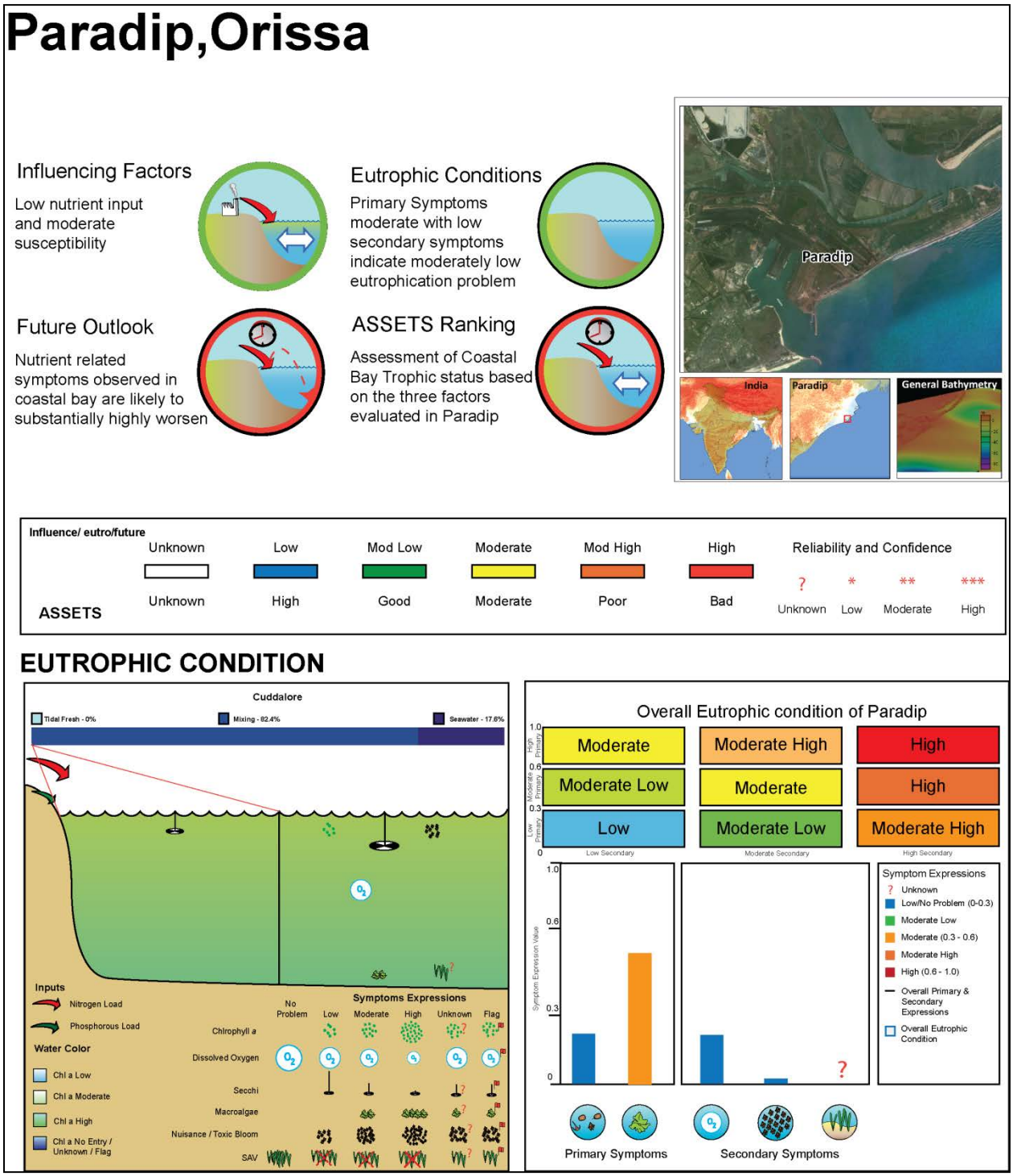


Fig 5.9: Eutrophication status of Puri coast, Orissa based on ASSETS Eutrophication Assessment

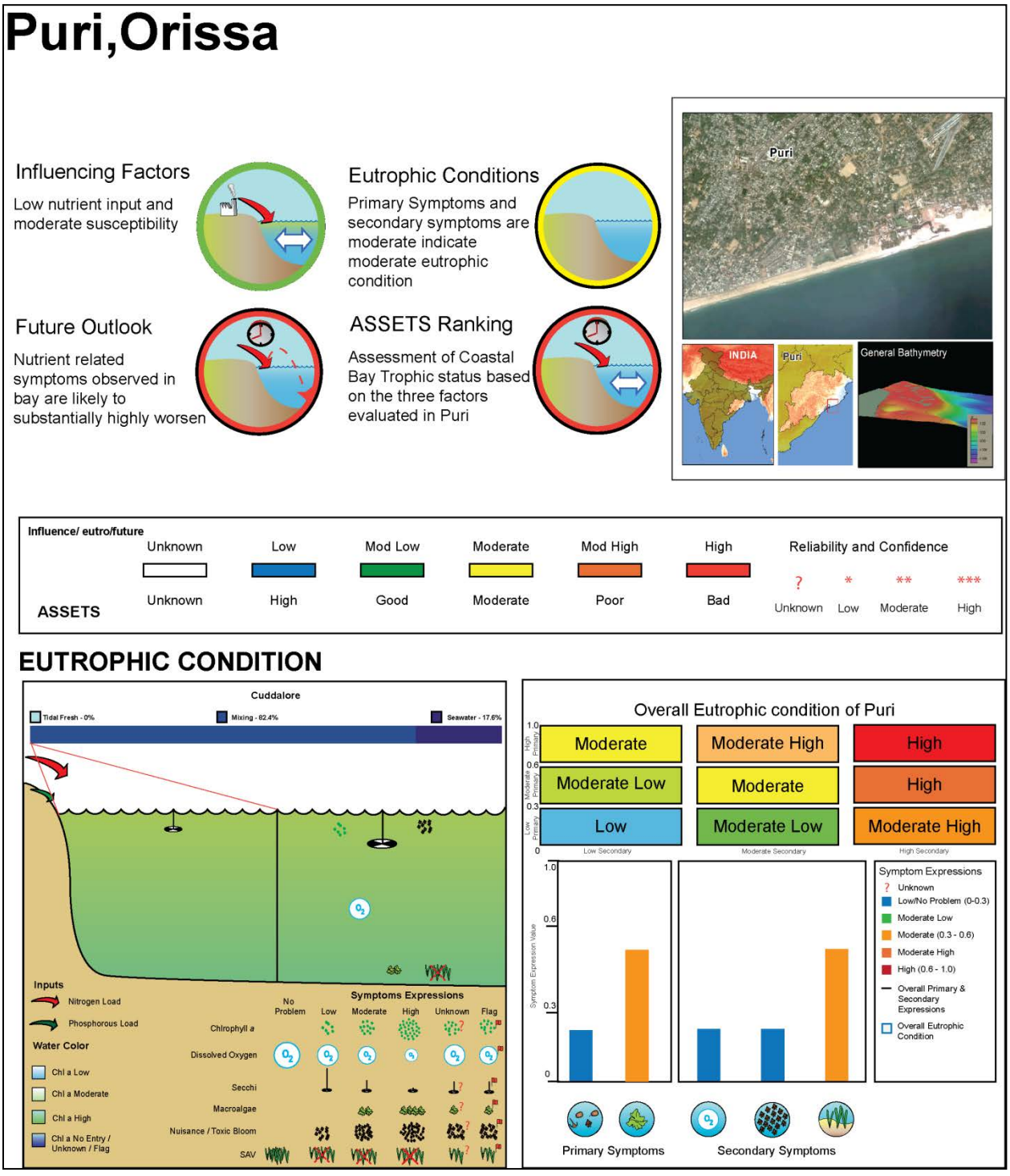
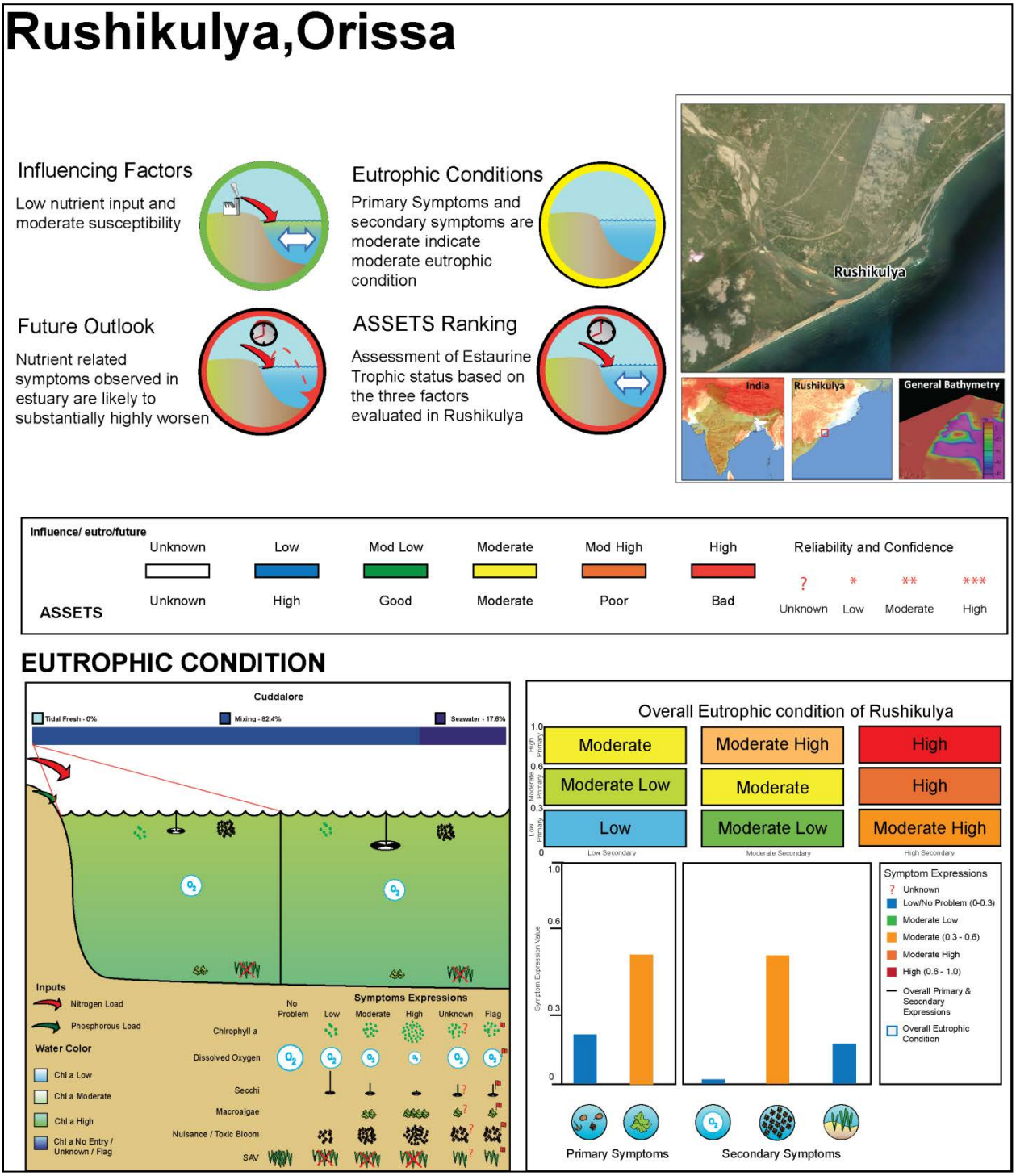


Fig 5.10: Eutrophication status of Rushikulya coast, Orissa based on ASSETS Eutrophication Assessment



5.1.3 Andhra Pradesh

Visakhapatnam is an important industrial city on the east coast of India. The coastal waters of this city, especially the harbour area, are polluted by the discharge of sewage and industrial wastes. The distribution and abundance of *Oscillatoria nigroviridis* and blooms of *Skeletonema costatum* are indicative of the polluted conditions in the harbour area. Coringa mangroves are situated south of Kakinada Bay, about 150 km south of Visakhapatnam. Blooms of *Thallassiosira decipiens* in Gaderu and *Bacillaria paradoxa* in South Bay were observed during May 1999. Enrichment of nutrients, favourable salinity conditions and surface runoff from agricultural fields could have resulted in eutrophic conditions, leading to algal blooms[10].

Fig 5.11: Eutrophication status of Kakinada coast, Andhra Pradesh based on ASSETS Eutrophication Assessment

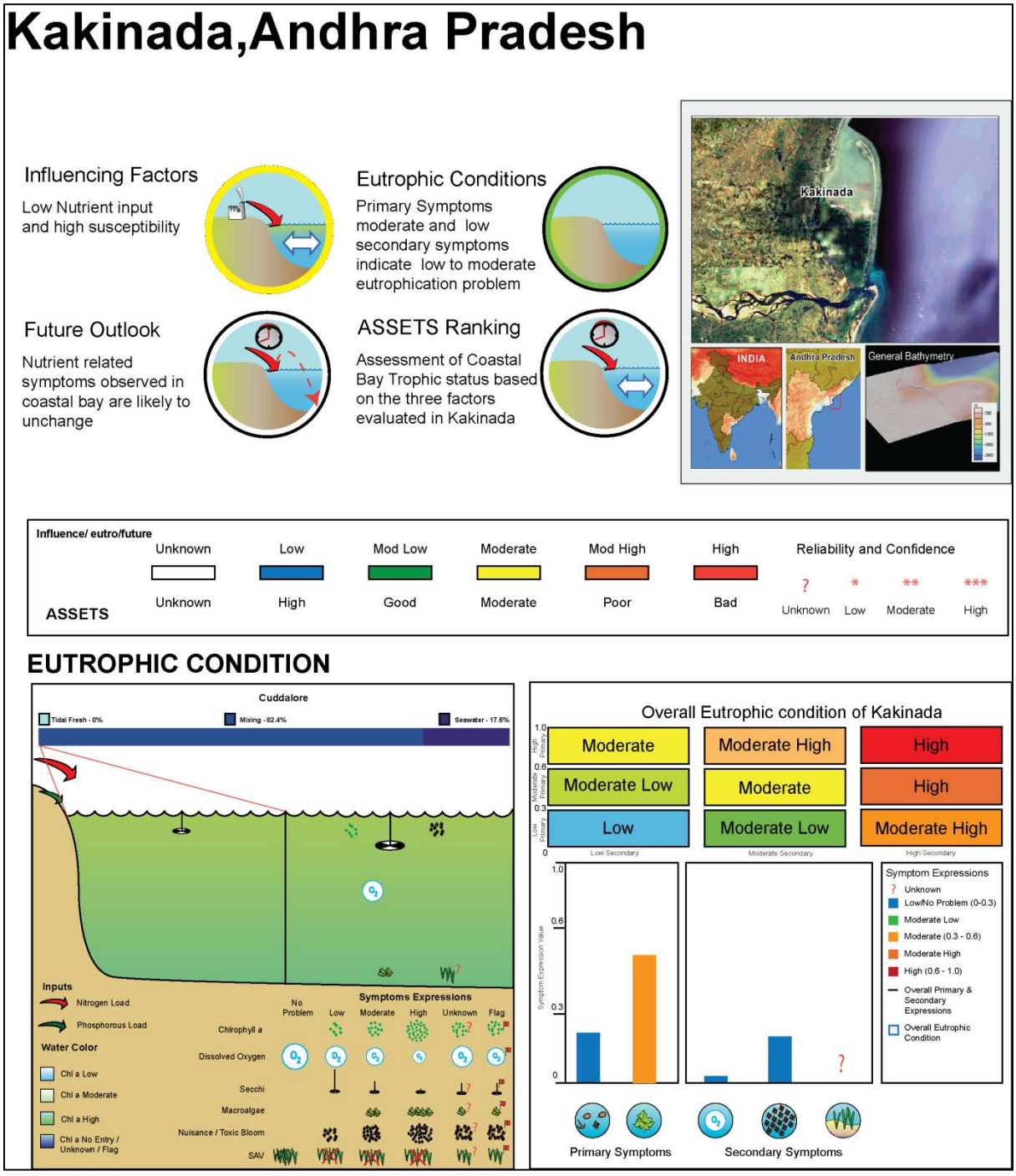


Fig 5.12: Eutrophication status of Nizampatnam coast, Andhra Pradesh based on ASSETS Eutrophication Assessment

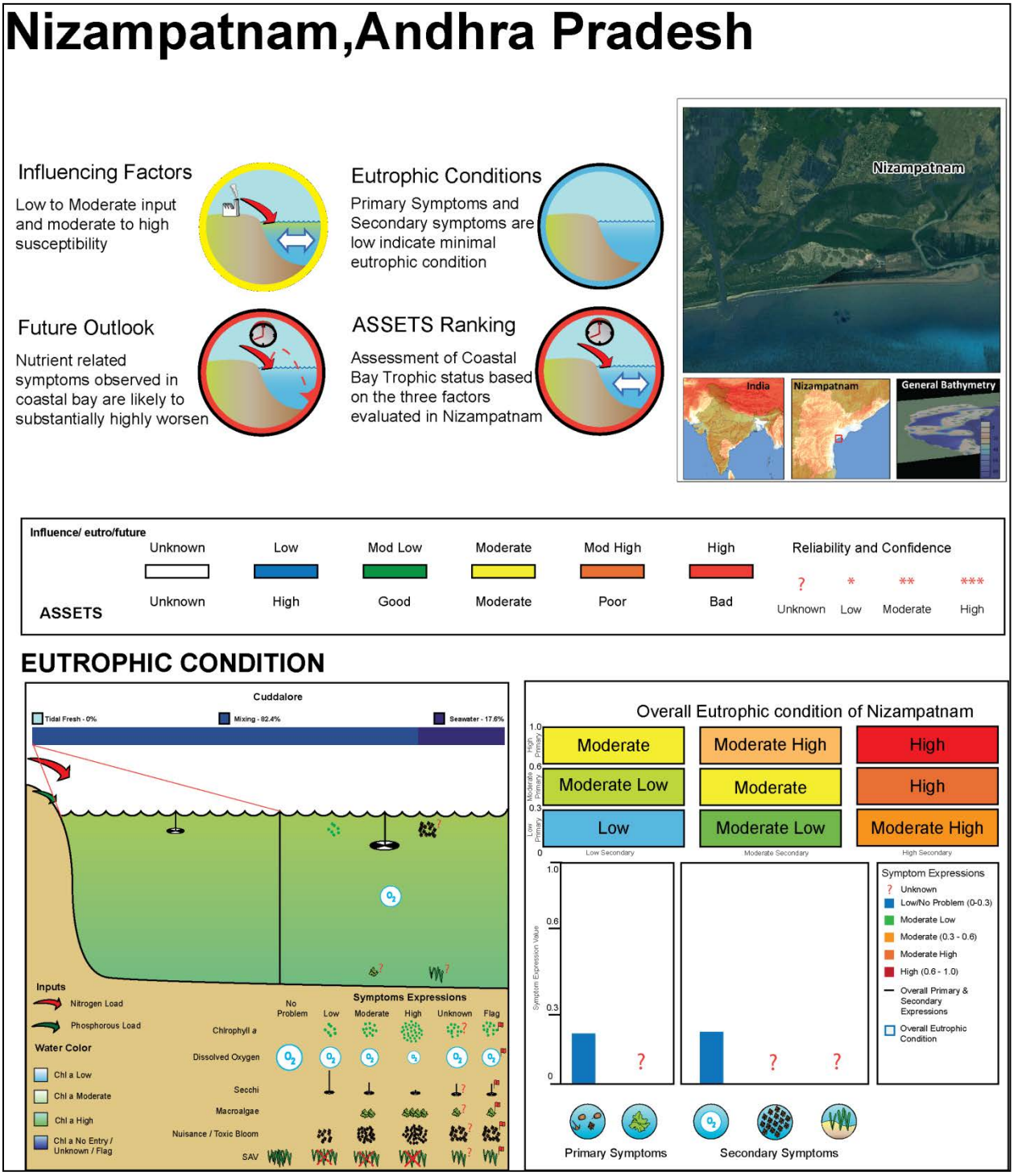
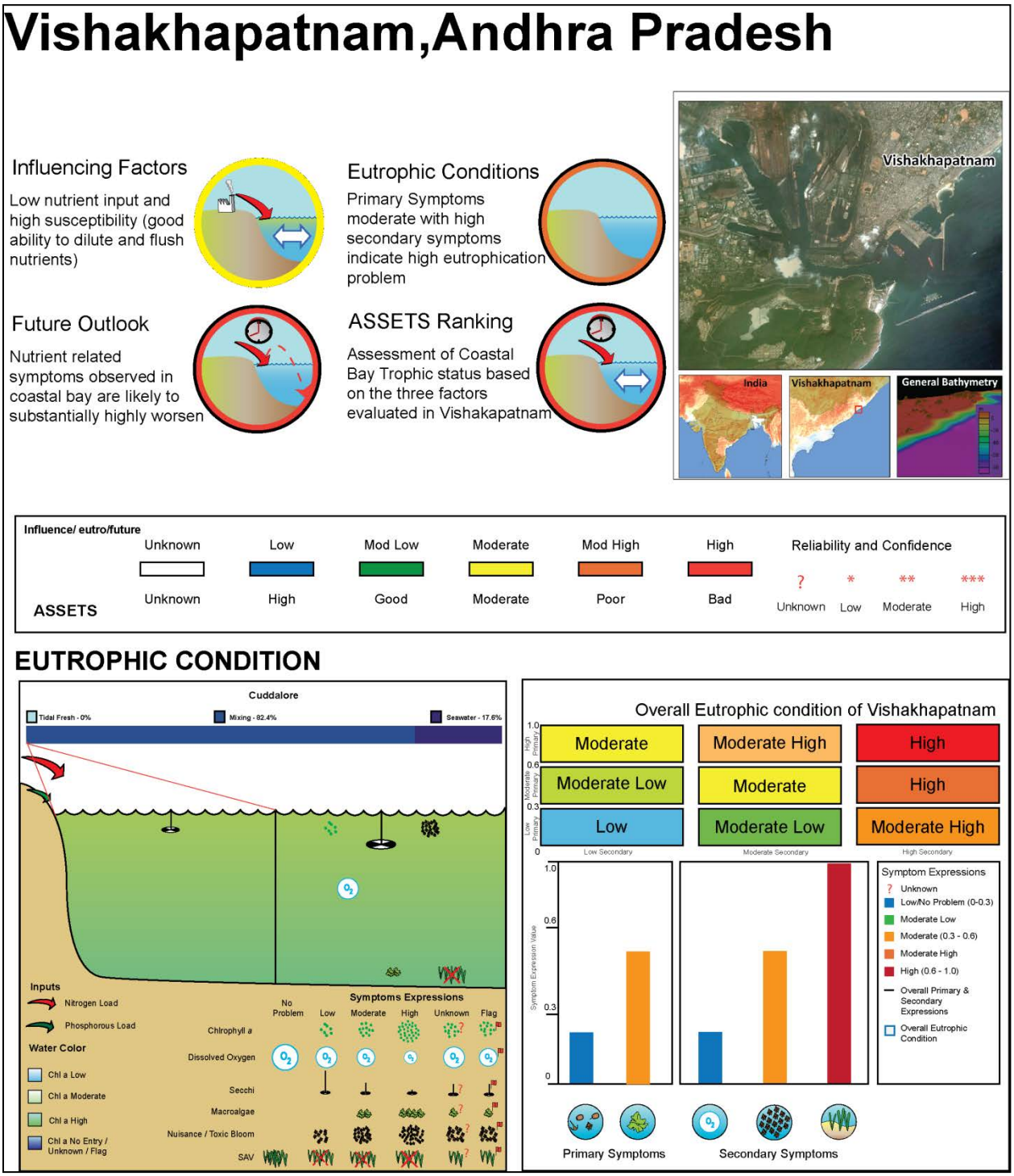


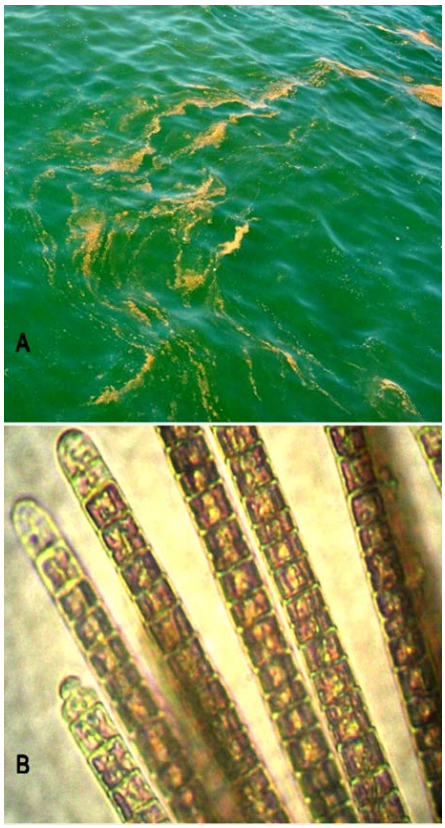
Fig 5.13: Eutrophication status of Visakhapatnam coast, Andhra Pradesh based on ASSET Calculation



5.1.4 Tamil Nadu and Puducherry

The discharge of the hot coolant water and the fly ash in Ennore creek and Buckingham canal has created appropriate conditions for algal blooms which get entangled with fishing nets and damages them. The blooming of phytoplankton *Lauderia borealis* was also recorded in Ennore, Cooum, Chennai harbour and Muttukadu of Chennai coastal waters. A prominent discolouration of the coastal waters by the blue-green alga *Trichodesmium erythraeum* was observed in the east coast of Kalpakkam during March 2007. The bloom which was very dense and created yellowish-green coloured streaks of about 4 to 5m width and extended to several meters, persisted only for a day exhibiting visible alteration in physico-chemical properties and phytoplankton community structure of the coastal waters. An increase in ammonia, total nitrogen and phosphate was also noticed on the day of bloom. *Trichodesmium erythraeum,* a marine cyanobacterium is an important nitrogen-fixer in the sea. It is one of the common bloom-forming species found in tropical and sub-tropical waters, particularly in the eastern tropical Pacific and Arabian Sea, contributing >30% of the algal blooms. The species has been identified as toxic and reported to contain neurotoxin commonly associated with paralytic shellfish poisoning (PSP)[11].

Fig 5.14: A photographic view of a) phytoplankton bloom and b) filaments of *Trichodesmium erythraeum* in the coastal waters of Kalpakkam, east coast of India taken on 16 March 2007 [12]



The rich biodiversity of at least two of the 21 islands in the Gulf of Mannar area off the Ramanathapuram coast in south Tamil Nadu, declared by the Centre as a National biosphere reserve, was considerably affected in October 2008 in the wake of an unusual “algal bloom” wave[13]. The marine park, stretching off the coast from Mandapam on the mainland up to Tuticorin suffered an ecological impact in a 30 km stretch from near Pamban to Keezhakarai. A sudden multiplication of the dinoflagellate *Noctiluca* in huge numbers had rapidly depleted the oxygen levels in the sea water, causing fish mortality along the coast. Corals got bleached due to lack of oxygen while many fishes and sea animals also died[14]. During the bloom phase, the coastal water in this stretch had turned dark green in colour. The phosphate and ammonia levels were

also very high. At several fish landing centres, massive blooming of the organism had reduced the oxygen level to between 1 and 1.2 ml l^{-1}.The size of the organisms was between 200 and 2000 microns. Although the blooming of *Noctiluca* had occurred a few times in Gulf of Mannar in the past, large-scale blooming happened only in the recent past. The outbreak of 'algal bloom' is linked to coastal marine pollution along the Gulf of Mannar due to indiscriminate dumping of municipal and domestic sewage. Absence of monsoon winds might have caused rapid multiplication of algal cells.

Fig 5.15: Satellite imagery of algal bloom in the coastal waters of Gulf of Mannar[15]

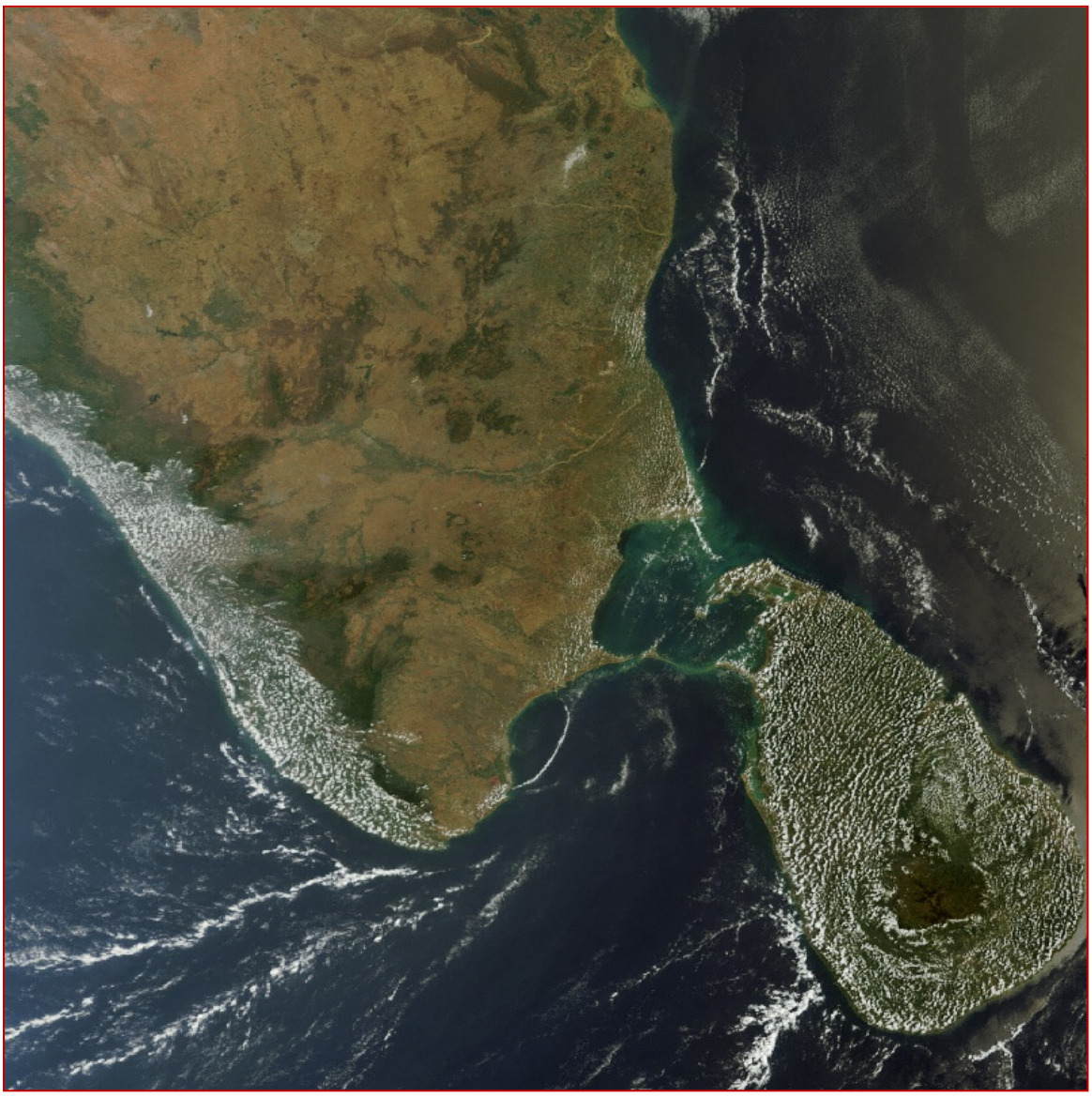


Fig 5.16: Eutrophication status of Pulicat coastal lagoon, Tamil Nadu based on ASSETS Eutrophication Assessment

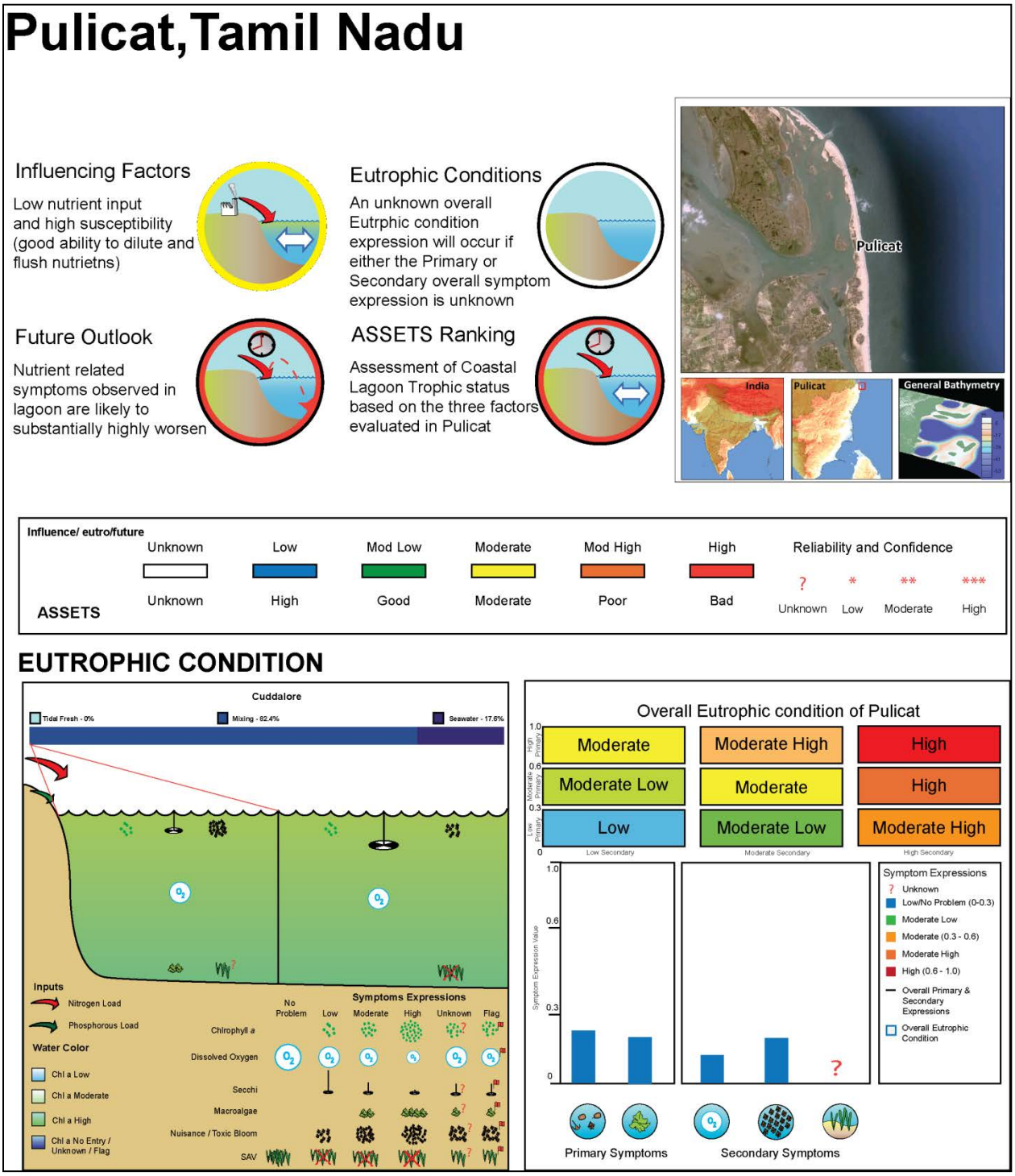


Fig 5.17: Eutrophication status of Ennore coast, Tamil Nadu based on ASSETS Eutrophication Assessment

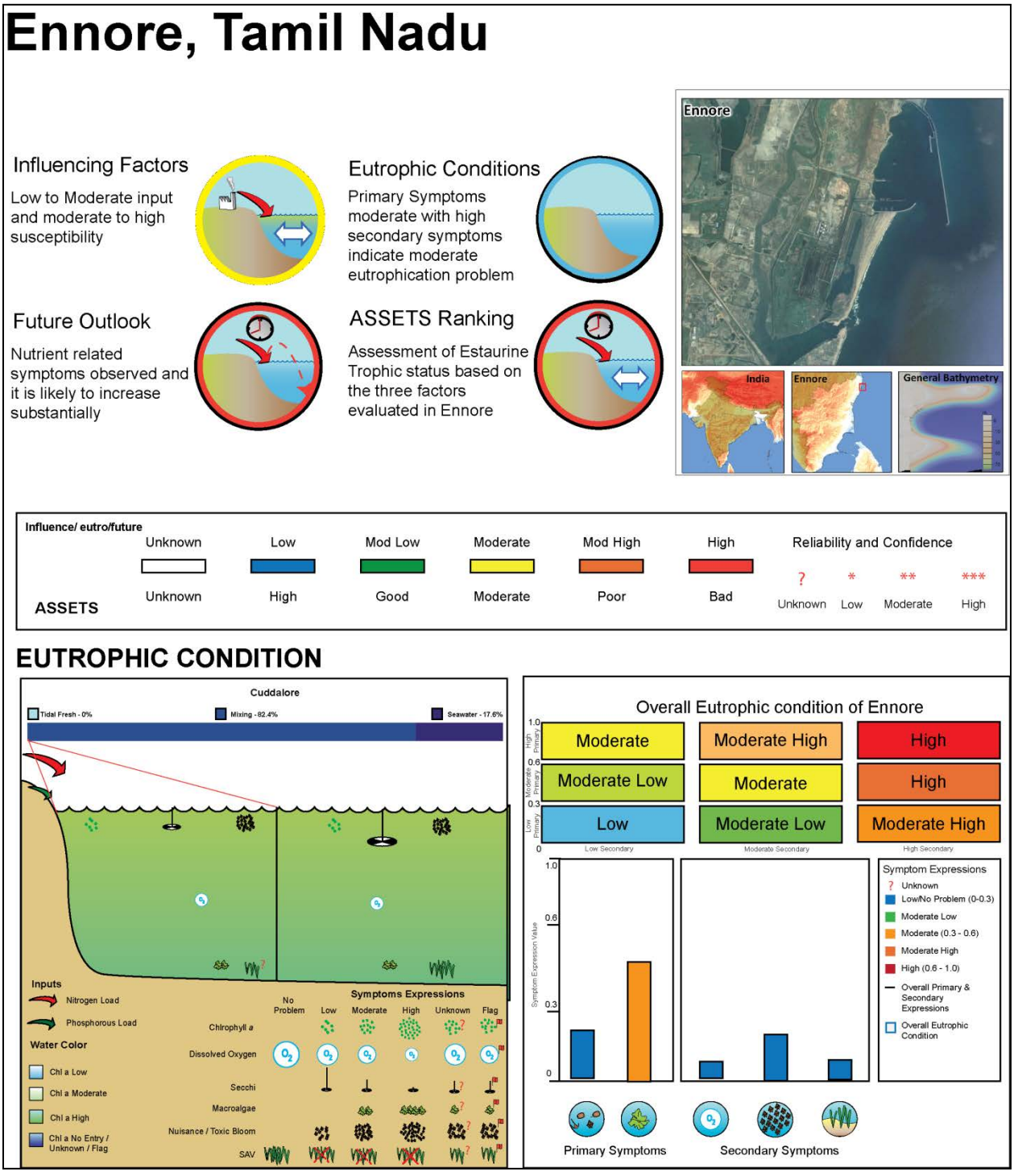


Fig 5.18: Eutrophication status of Mahabalipuram coast, Tamil Nadu based on ASSETS Eutrophication Assessment

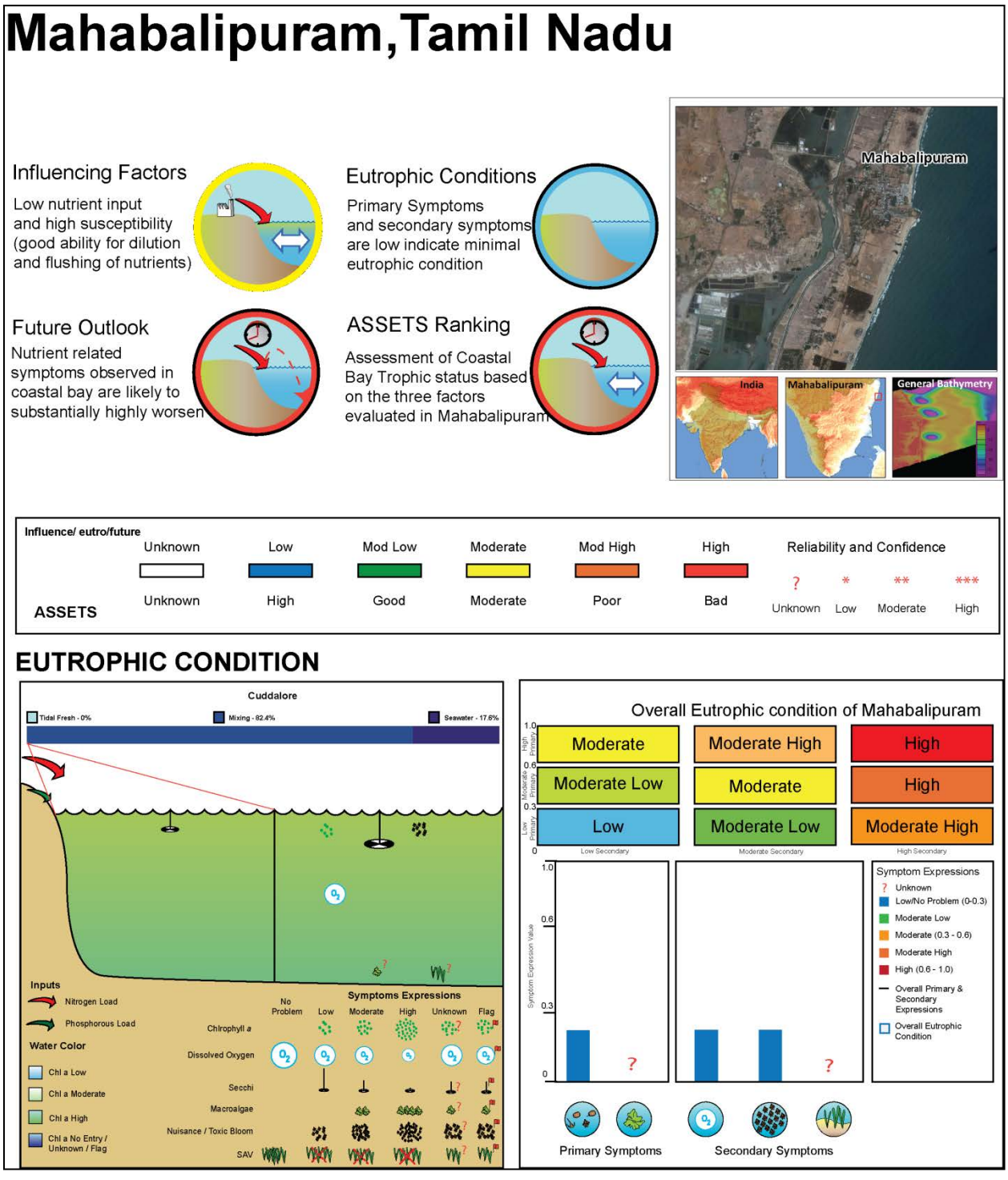


Fig 5.19: Eutrophication status of Puducherry coast, Tamil Nadu based on ASSETS Eutrophication Assessment

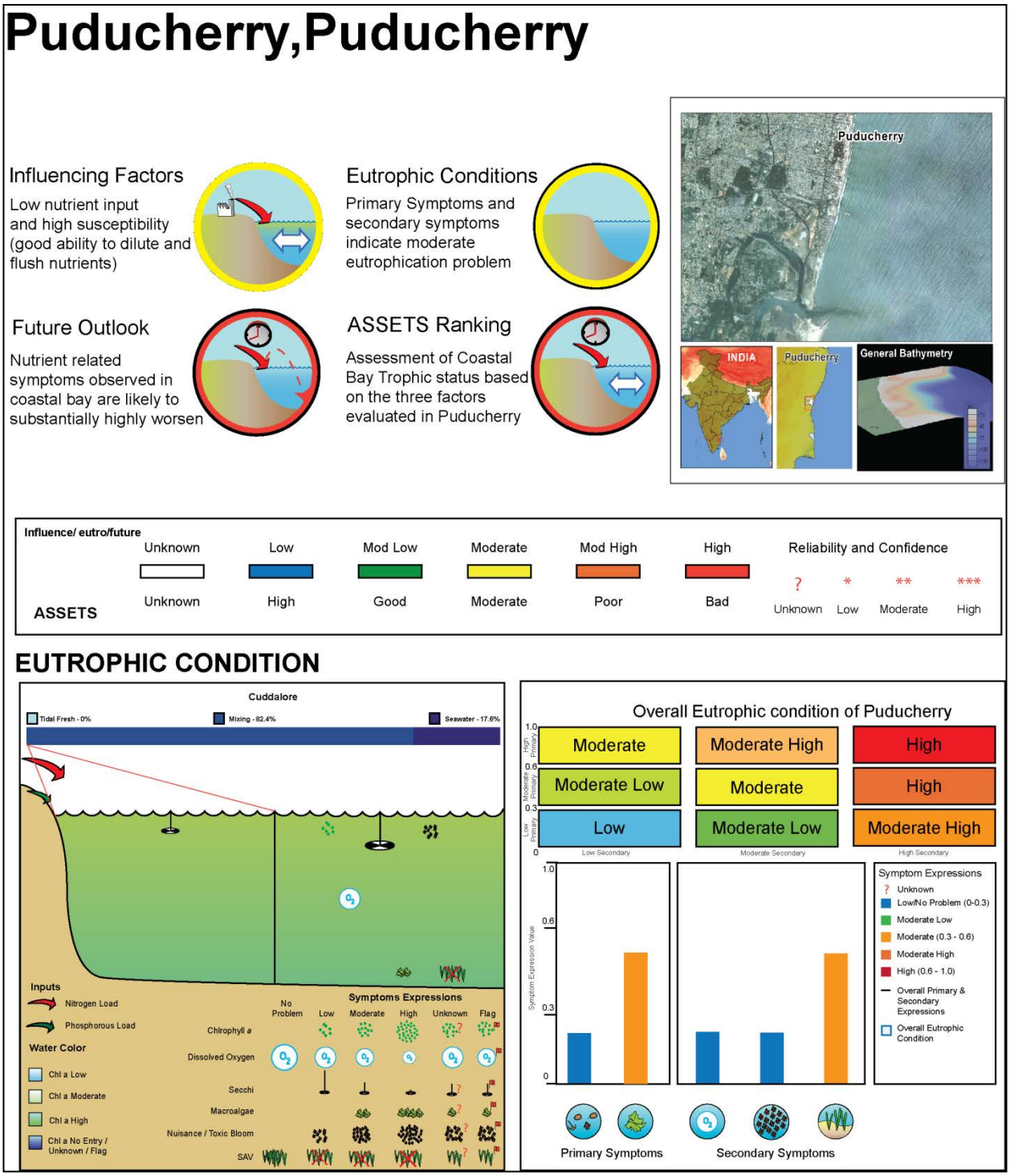


Fig 5.20: Eutrophication status of Cuddalore coast, Tamil Nadu based on ASSETS Eutrophication Assessment

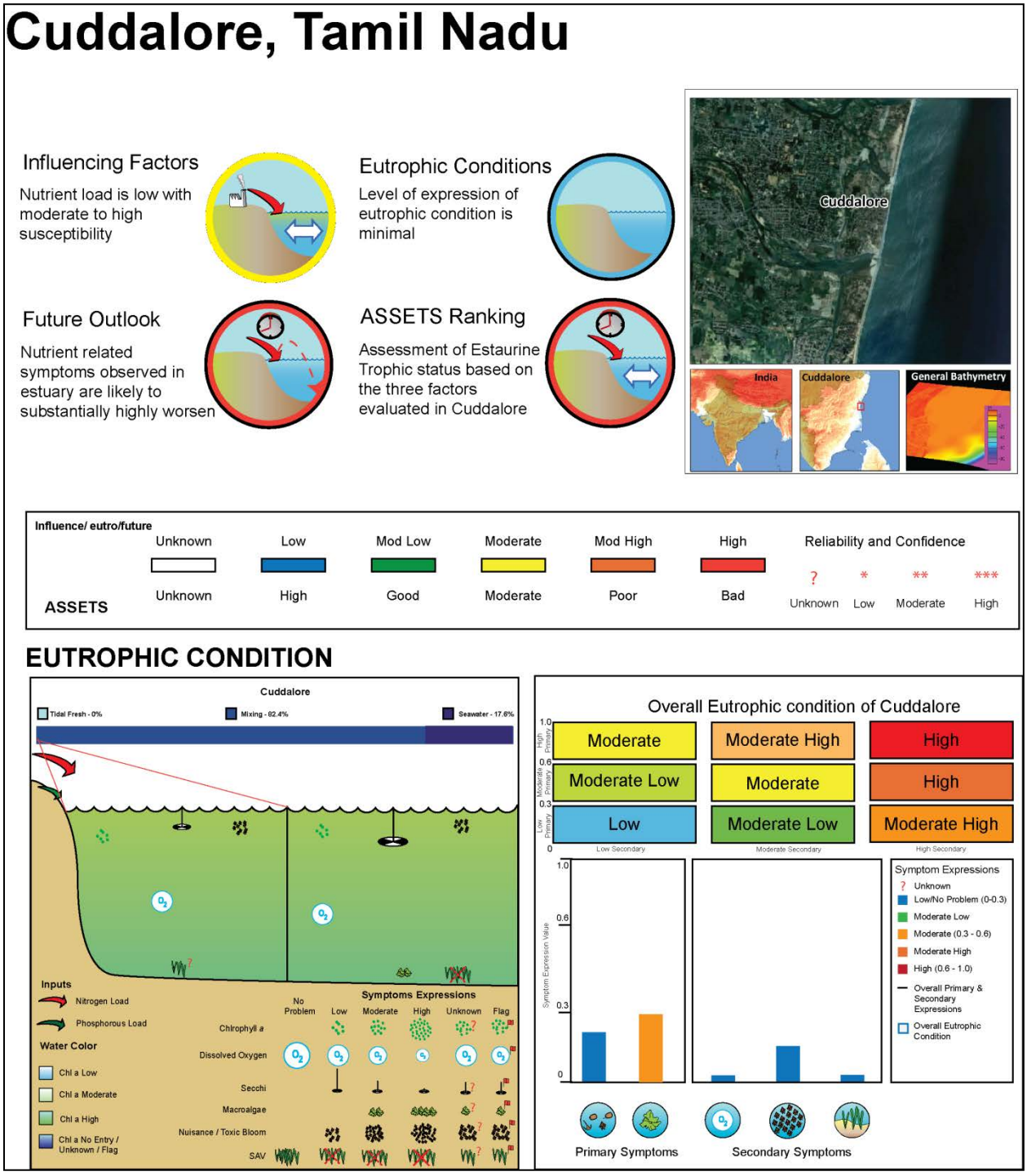


Fig 5.21: Eutrophication status of Karaikal coast, Puducherry based on ASSETS Eutrophication Assessment

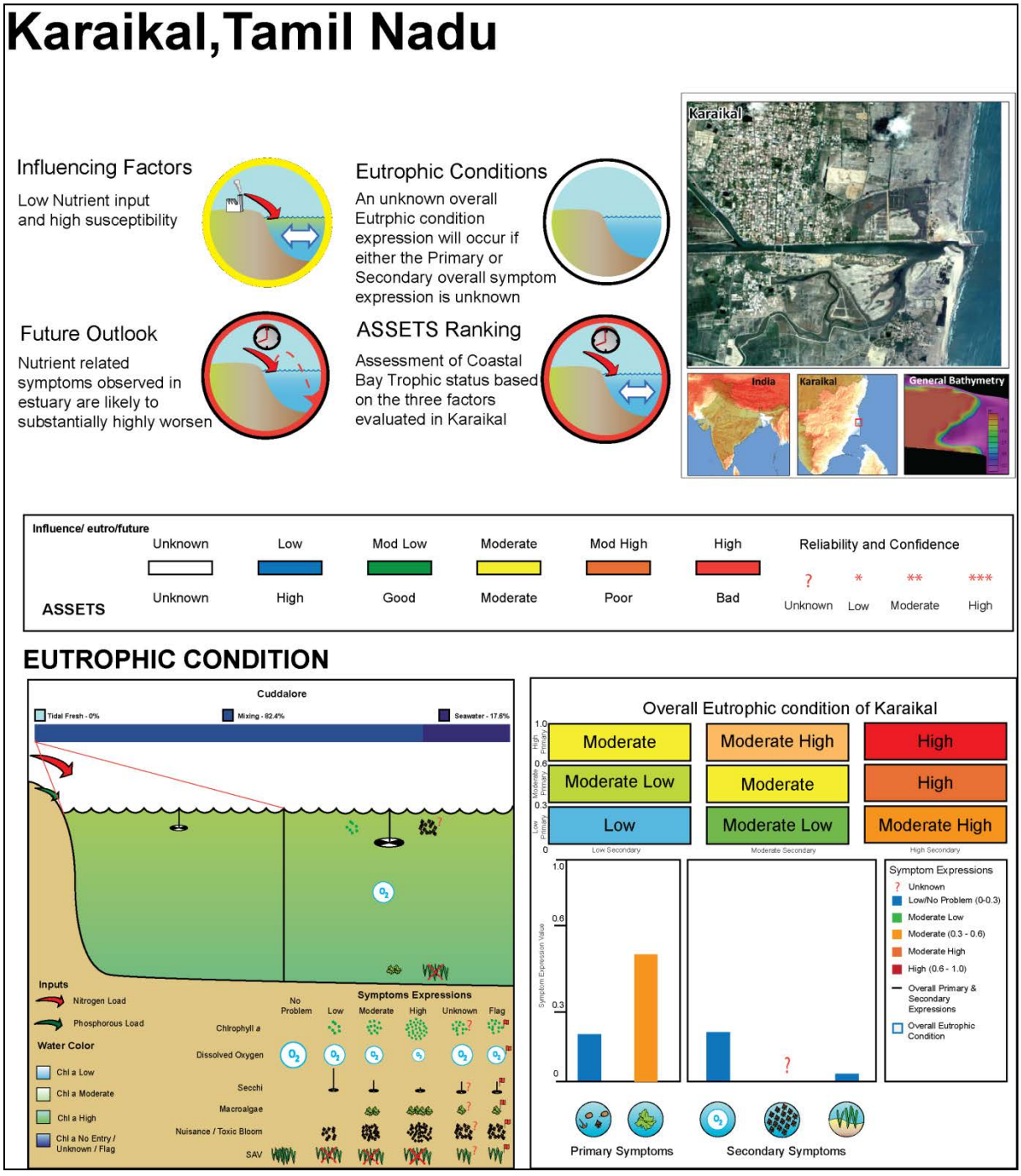


Fig 5.22: Eutrophication status of Mandapam coast, Tamil Nadu based on ASSETS Eutrophication Assessment

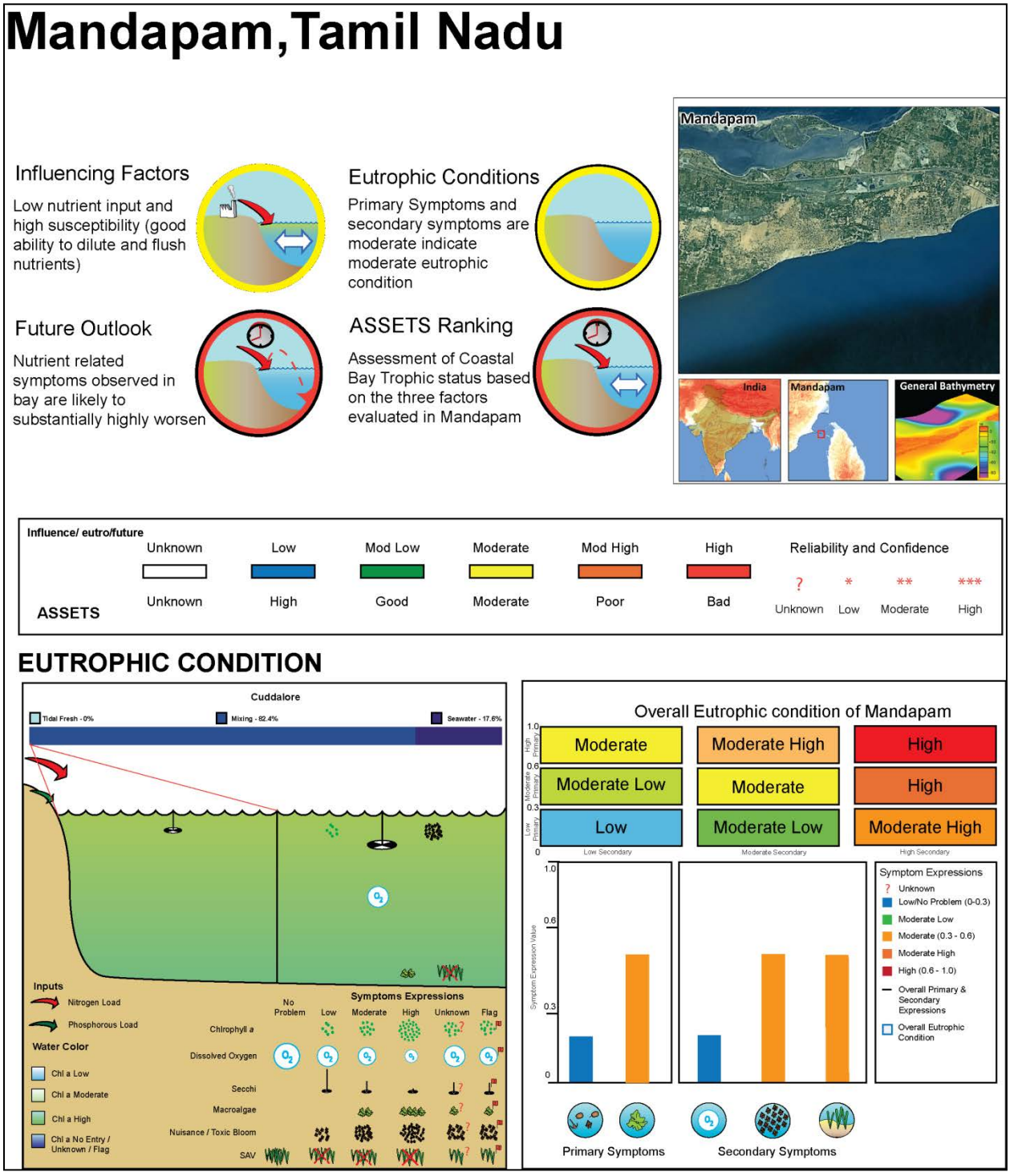
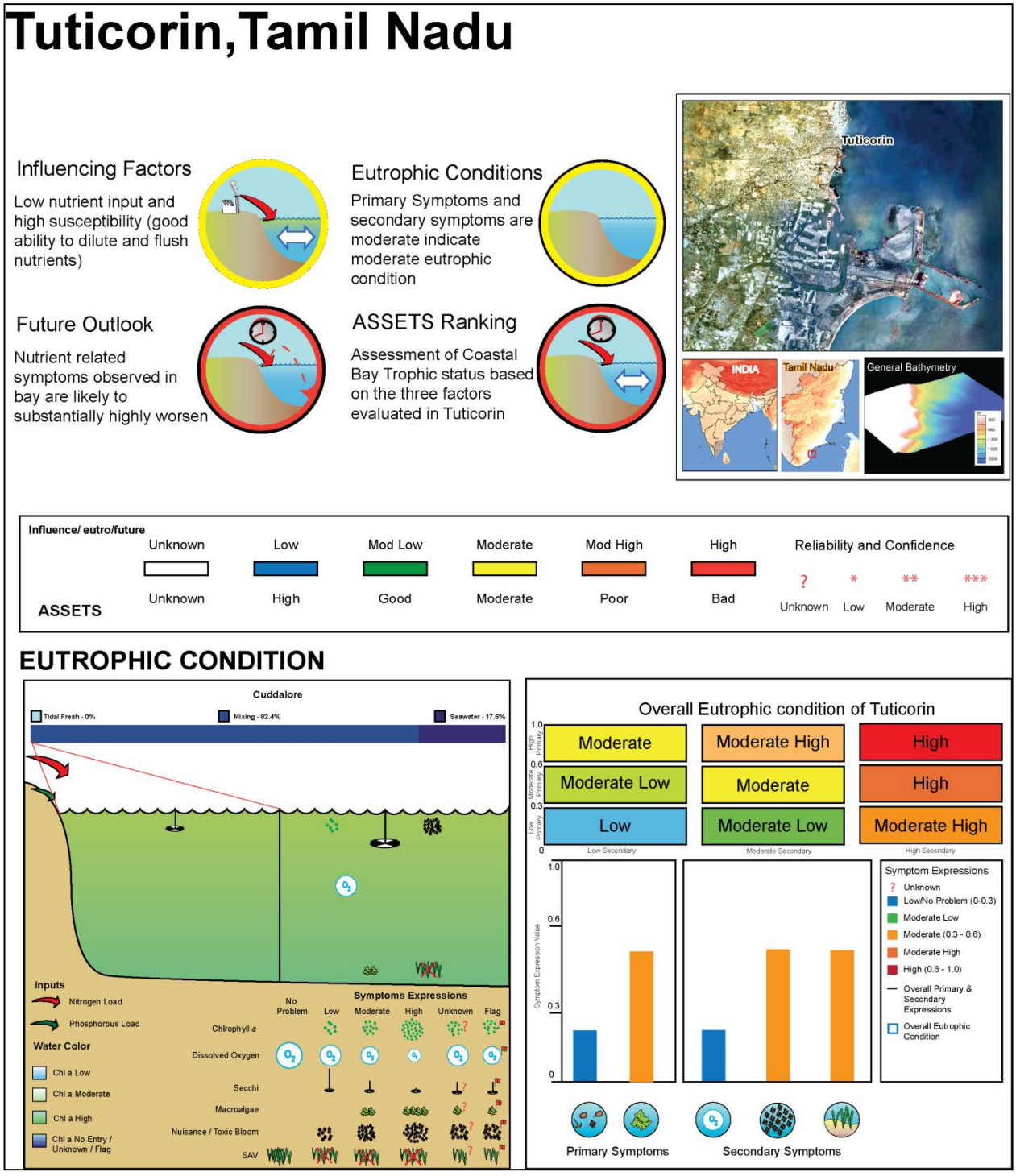


Fig 5.23: Eutrophication status of Tuticorin coast, Tamil Nadu based on ASSETS Eutrophication Assessment



5.2 Oil Pollution, Oil Spills and Ecological impacts of Oil Pollution

UNO's International Maritime Organizations identifies oil spills to be the single most dangerous hazard for the marine environment[16]. The types of spills that are most often seen are accidental spills from tankers which account for about 20% of the oil. Pollution due to oil exploration and mining, oil refining, oil transportation, oil spills and bilge discharge from ships and fishing trawlers, as well as from petrochemical industries, is also present in some locations such as Tamil Nadu and Andaman and Nicobar islands. The Bay of Bengal has been estimated to receive around 4 x 10^6 t/y petroleum annually, respectively from routine discharges from oil tankers and other ships plying the shipping lanes originating from the Middle East. Consequently, tar balls and oily residue are a common sight on many beaches of countries including India, bordering Indian Ocean. The range of concentrations of dissolved hydrocarbons in the Bay of Bengal is 0-28.2 µg/kg with an average 4.6 µg/kg. The particulate petroleum residues range from 0-69.8 mg/m^2 in the Bay of Bengal.

India relies heavily on the marine environment for trade and commercial operations. Two major oil choke points of the world – Strait of Hormuz and Strait of Malacca lie on the west and east coast of India. Due to the narrowness of these lanes, the routes are accident prone. Some of the major oil spills in different regions of the Bay of Bengal Coast (Table 5.1) are discussed in the following section along the coastal states of India from West Bengal in the North to Tamil Nadu in the South.

Table 5.1 Major Oil spills on the East Coast of India since 1970[17]

Date	*Quantity / Type of Oil Spill (tonnes)*	*Position*	*Vessel/Other Incidents*
Sep 1991	692.5 (Fuel Oil)	Gulf of Mannar, Tamil Nadu	MT, *Jayabola*
Feb 1992	Not estimated (Tanker wash)	40n mile south of New Moore Island, Bay of Bengal	Unknown
Aug 1992	1060 (Kerosene Oil)	Madras Harbour, Tamil Nadu	MT *Albert Ekka*
Jan 1993	40000 (Crude Oil)	Off Nicobar	Maersk Navigator
Mar 1993	NK/crude	Off Narsapur, Andhra Pradesh	ONGC shore rig, Kumarada
Nov 1994	288 (Heavy Oil and Diesel)	Off Madras, Tamil Nadu	MV *Sagar*
Mar 1994	200 (Diesel)	Off Vizag, Andhra Pradesh	Dredger *Mandovi-2*
Nov 1995	Not Estimated (Tanker wash)	Eliot Beach, Chennai	Unknown
May 1996	370 (Diesel) / IOC chartered Barge)	Off Hooghly River	MV *Prem Tista*
Jan 1997	Not Estimated (Heavy Fuel Oil)	Kakinada coast, Andhra Pradesh	Unknown
Jun1997	Not Assessed (Heavy Fuel Oil)	Hooghly River, West Bengal	MV *Green Opal*

Sep 1997	Naptha, Diesel, Petrol	Vizag, Andhra Pradesh	HPC refinery
Jul 2000	-	Off Sagar Island, West Bengal	MV *Prime Value*
Jul 2001	-	Hooghly River, West Bengal	MV *Lucnam*
Sep 2002	-	220 nm, off Pt Calimare	MV *Hiderbahy*
May 2003	145/ FFO	Off Haldia, West Bengal	Mv *Segitega Biru*
Jun 2005	49, 537/cargo and 640/FO	Visakhapatnam Port	MV *Jinan VRWD-5*
Jul 2005	33/FO	NE of Paget Island(N Andaman)	MV *Edna Maria*
Aug 2005	08	9 nm Sunken Ship off Tuticorin	MV *IIDA*

Table 5.2: Concentration of Petroleum Hydrocarbons (PHc) along the East coast of India[18]

Location	PHc (µg/l)	Standard
Bay of Bengal	0.8-5.2	Saudi Arabian Crude
Andaman Sea	28-83	Arabian crude
Great Channel	0.32-1.85	Saudi Arabian Crude
Kakinada Bay	1.6-14.8	-
Visakhapatnam Harbor	11.5-123.8	-
Harbor area of Chennai	11-139	Arabian crude

5.2.1 West Bengal

The risk of oil pollution is high due to the oil tanker line of Kolkata and Haldia port due to accidental releases as well as deliberate dumping of bilge water.

5.2.2 Orissa[19]

A major oil spill has occurred in the undersea portion of the Paradip- Haldia pipeline in the Paradip coast and it is estimated that 2,000 to 3,000 tons of crude oil has been leaked out in the sea[20]. Since the summer currents are in the northward direction of the coast, these crude spills are expected to wash up at Gahirmatha which is only 15 kilometers away from Paradip port which damage the turtle feeding grounds in the wildlife sanctuary. Turtles feed on benthic fauna like mollusk, sea worms, star fish, anemones, sea cucumber, etc. Once the oil covers this area, the fauna will die out and the resulting pollution will prevent their regeneration for a long time. Crude oil is a very persistent pollutant and marine oil spills in the past have lead to disastrous loss of marine wildlife and habitat. Fish breeding grounds are destroyed by such spills.

Hundreds of fish have died and thousands of endangered sea turtles and their eggs face a threat due to an oil leak from an Indian ship 2 km off Orissa's coast near Gopalpur port. A coal-carrying Indian ship sailing from Indonesia that hit a berth at Gopalpur port in Ganjam district of Orissa during April 2010[21] started leaking oil endangering the lakhs of eggs of marine Olive Ridley turtles on Rushikulya beach. An

oil coat was found spread over a 7 km area off the beach – just 200 metres from the site of the eggs. Marine fauna which form the food for the turtles will be severely affected by the oil.

Fig. 5.24 : Distribution of oil spill pollution in Bay of Bengal

5.2.3 Andhra Pradesh[22]

The port city Visakhapatnam is at high risk of oil spills. The level of PHc in the harbor waters of Visakhapatnam is estimated to be 186 µg/l[23]. Kakinada port also another vulnerable area for oil pollution. Because of this port, the risk of oil spill impact is high for the nearby Coringa mangroves (Godavari delta).

5.2.4 Tamil Nadu

Activities responsible for oil pollution of the environment in Tamil Nadu include oil exploration, oil refining, oil transport, oil spills and leakages from ships and fishing trawlers as well as from petrochemical industries. The Petroleum Hydrocarbon concentrations in the sediments vary over a wide range of 1.48 to 4.23 ppm. The highest concentration (4.23 ppm) occurs at Narimanam, Nagapatinam District, Tamil Nadu, which receives hydrocarbon contents from oil refineries. The concentration of petroleum hydrocarbon at Parangipettai is low (1.48 ppm), which is considered as a baseline for petroleum hydrocarbon in this region. The PHC in Bay of Bengal is comparatively lower than in the Arabian Sea. High PHC content in the harbor waters of Chennai and Elliot Beach (4 – 11,059 µg/l) was due to an oil spill that affected the area in the recent past[24].

Table 5.3 Activities related to marine oil pollution in Tamil Nadu[**25**]

Activity	Area	Other Details
Oil exploration (drilling wastes, production wastes and sanitary waste)	Kareri Delta, Palk Bay	Off shore and Near shore
Oil production (same as above plus free emulsion tank bottom sludge etc.)	Koilkalappat, Narimanam, Bhuvanagiri	25.000 t 30.000 bbl/d
Oil transport (ship wastes, tank washings, spills etc.)	Chennai and Tuticorin	$3x10^6$ t/y
Oil refining (oil from leaks, spills, effluents tanks draw off etc.)	Chennai	5xld t/y
Petrochemicals production (by products production and industrial wastes)	Chennai Gulf of Mannar	75,000-100, 000 t/y

The frequent oil spills in Tuticorin and Gulf of Mannar affect the coral islands close to Gulf of Mannar. The dissolved PHC in the Pichavaram mangrove waters ranged from 5 to 15 µg/l and in Kodiakkarai from 8 to 20 µg/l. Whereas, in the coastal waters of Chennai the values are ranging from 4 µg/l to as high as 108 µg/liter in water and ranging 1.5 to 3.5 µg/g dry weight in sediments were reported.

5.2.5 Andaman and Nicobar Islands

The Andaman and Nicobar Islands comprise about 348 islands of volcanic origin occupying an area of about 8249 km² in the Bay of Bengal. The International tanker route is located south of Indira point at Greater Nicobar. A few oil spill incidences have occurred in the past in this area with a major one during 1993. Oil slicks, tar residues and dissolved petroleum hydrocarbons (DPH) shortly after the oil spill resulting from a tanker accident in January 1993 showed negligible impact on the Indian EEZ of the Great Channel (Andaman Sea). DPH were between 0.31 and 1.85 µg l^{-1} in this area caused damage to coral reefs.

5.3 Persistent Organic Pollutants (POPs) and Heavy metals in the Bay of Bengal Coast

5.3.1 Persistent Organic Pollutants (POPs)

POPs are characterized by low water solubility and high lipid solubility; they bioaccumulate and biomagnify through the food web. They are also semi-volatile, a property which permits these compounds either to vaporize or to be adsorbed on atmospheric particles. Hence POPs have the ability of long-range transport in air and water from warmer to colder regions of the world. Among the PoPs are several pesticides which have both point and non-point sources. Point sources of POPs pesticides are from pesticide manufacturing facilities (both technical grade manufacturers as well as formulators) and stockpiles of obsolete, unwanted or date expired pesticides. Non-point sources arise due to the general application of pesticides in cultivation resulting in crop run offs or leaching into coastal waters through river runoff. Recent surveys indicate significant levels of DDT, PCBs and dieldrin in nearshore as well as offshore fish samples in the Bay of Bengal[26]. POP residues in aquatic and marine life are indicative of contamination of water sources in the food chain. In India, dolphins, which are at the highest level of the food chain in large river systems, contain excessively high levels of DDT, chlordane, aldrin, dieldrin, heptachlor, HCB and PCBs, far in excess of standards for edible meat[27].

5.3.2 Heavy metals

Trace metals are introduced into the coastal zone environment by the anthropogenic activities and are absorbed/incorporated into the sediments. A major part of the metals accumulate in the estuarine and the continental shelf regions which are the important sinks for the land derived activities[28]. Geochemical cycle of trace metals in the coastal zone environment is an important process to determine the present level of metal enrichment which has been deposited via a number of ways through rivers, other

industrial and domestic effluent inputs[29]. However, in recent years in Bay of Bengal there have been many instances where metal contamination in coastal sediments took place due to the local anthropogenic industrial effluents and other sources[30]. The distribution of heavy metals in various coastal regions of the Bay of Bengal (Figs. 5.25 and 5.26) are discussed in the following section from West Bengal in the North to Tamil Nadu in the South.

Fig. 5.25: Heavy metal pollution in coastal waters of Bay of Bengal

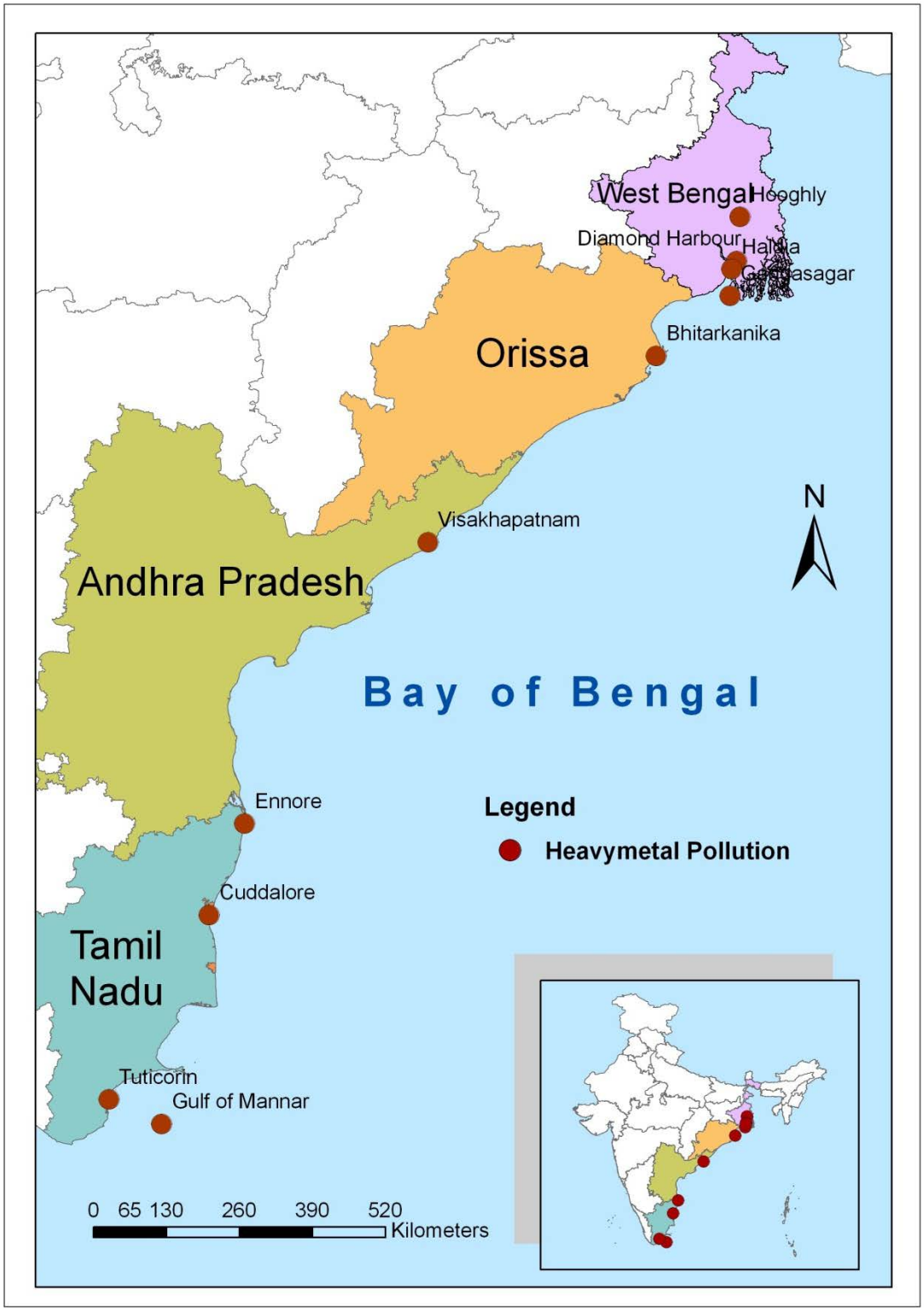
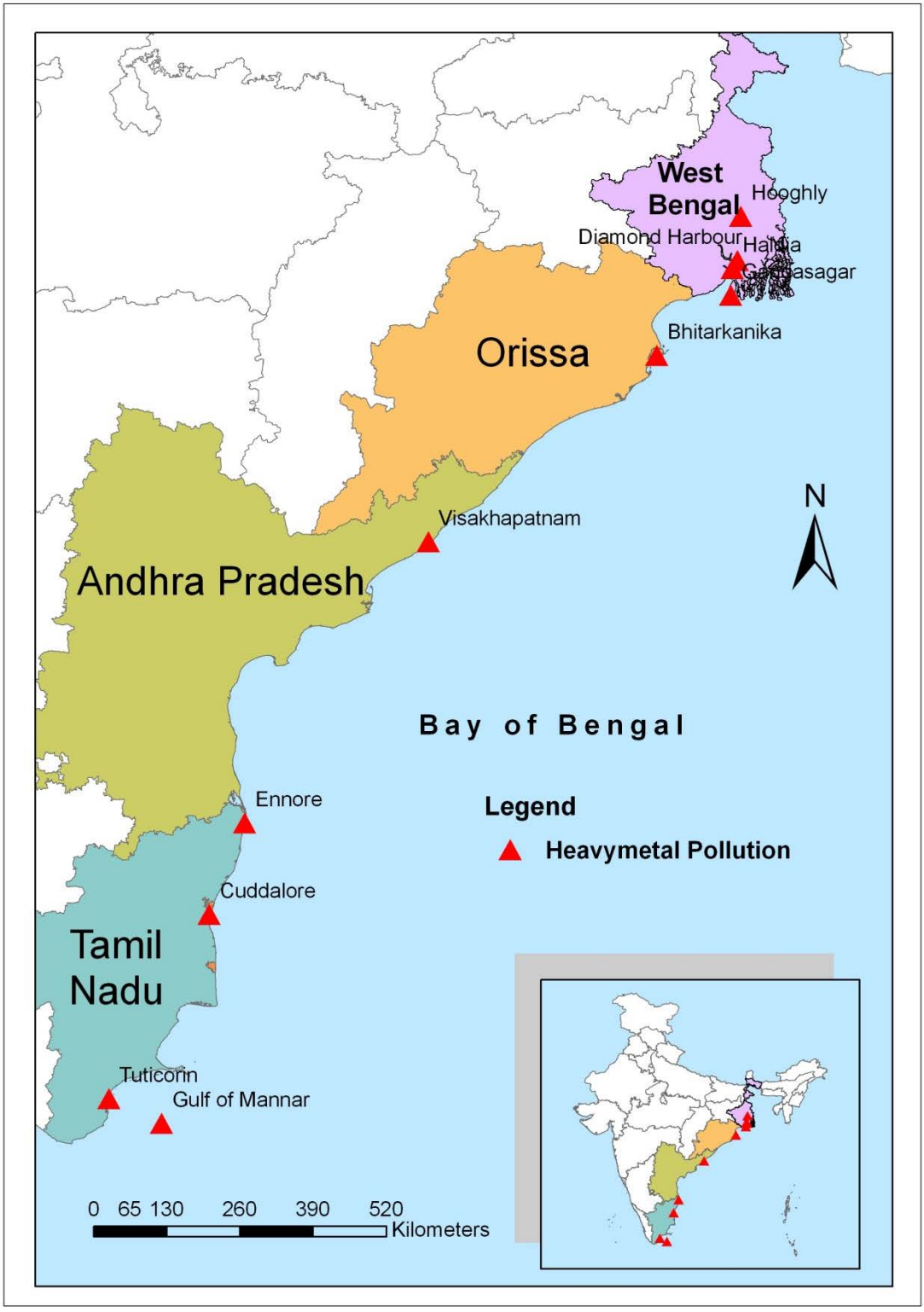


Fig. 5.26: Heavy metal pollution in coastal sediments of Bay of Bengal



5.3.2.1 West Bengal

Heavy metal concentration in marine fish such as *Liza parsia, Pampus argenteus, Lepturacanthus gangeticus, Daysciaena albida, Eleutheronema tetradactylum* and *Polynernus paradiseus* indicate high accumulation of Pb, Cd and Zn due to industrial pollution.

- The high concentration of zinc in the muscles of the fish samples is mainly due to the presence of a large number of fishing vessels and trawlers which use galvanized metal coatings to prevent rusting, that ultimately find its way into the ambient media through leaching.
- The high levels of copper may be attributed not only due to the presence of antifouling paints used in trawlers, but also to the extensive use of coal-tar which has copper as an important ingredient. Moreover, local aquacultural farms which use copper sulphate as an algicide can also be regarded as a source of copper pollution.
- The extremely high values of lead in the samples indicate that the environment is highly stressed with respect to lead.

The run-off land derived sources during monsoon is also an important factor behind high metal levels in the fish tissues.

Table 5.4 Concentrations of heavy metals Zn, Cu, Pb (mg kg^{-1} dry wt.) in various fishes

Specimen	Zinc	Copper	Lead
Pampus argenteus	1.5	5.5	98.5
Lepturacanthus gangeticus	1.7	4.0	64.5
Daysciaena albida	1.5	2.5	86.0
Liza parsia	11.5	6.0	76.0
Polynemus paradise us	*B.D.L	1.0	62.5
Eleutheronema tetradactylum	2.5	1.0	48.5

5.3.2.2 Orissa[31,32,33,34]

The Bhitarkanika mangroves (lat 20° 4’ N; long 86° 45’ E) are located in the state of Orissa on the east coast of India and situated in the deltaic region of Brahmani and Baitarani rivers. A study on the contamination by heavy metals in sediments and mangrove leaves indicate high concentration due to riverine pollution.

5.3.2.3 Andhra Pradesh

Trace metals in water and phytoplankton of Visakhapatnam harbour area, east coast of India was studied by Subramanyam and Ananthalakshmi[35]. They reported that

concentrations of Fe, Mn, Cu, Ni, Zn, Pb, Cd and Co in the surface and bottom were higher in water and in mixed phytoplankton samples in the harbour as compared to their concentration level in coastal waters. Though the trace metal concentrations in coastal waters are higher than the average values of the Indian Ocean, they were however, lower than those reported for coastal and inshore waters of the Bay of Bengal. Significant correlations are observed between some trace metals in water and phytoplankton, indicating their common association with them.

Tamil Nadu [36,37,38,39,40,41]

Cuddalore

The Cuddalore town, located in the northeastern part of Tamil Nadu, hosts a number of large-scale industries. Three rivers, Uppanar, Ponniar and Gadilam confluence with the Bay of Bengal in the vicinity of Cuddalore. This area was reportedly a good nursery for the marine fauna a few decades ago. Presently various industrial activities pollute the coastal areas and estuaries in the Cuddalore region and this is evident in the high concentrations trace metals such as cadmium, lead and zinc in water samples. Coastal surface waters indicate enrichment of dissolved Mn in water due to the diffusion of Mn from the underlying sediments. Dissolved Pb, and Zn values in Cuddalore coastal waters indicate severe anthropogenic pressure. A summary of the values of various trace metals in water samples from the Bay of Bengal is given in Table 5.5.

Table 5.5 Comparison of average concentrations of dissolved trace metals in Bay of Bengal region, Southeast coast of India

Study Areas	Fe	Mn	Cr	Cu	Ni	Pb	Zn	Cd	References
Inshore/coastal waters of Bay of Bengal	69.0	13.5	ND	4.7	6.1	ND	9.0	ND	Qasim and Sen Gupta (1980)[42]
Coastal region of Visakhapatnam, Bay of Bengal	15.1	3.3	ND	2.2	1.7	6.0	23.7	1.0	Satyanaryana et al. (1985)[43]
Coastal waters of northern Bay of Bengal	16.9	3.5	ND	2.3	2.0	6.7	25.3	1.0	Satyanarayana et al. (1987)[44]
Coastal waters of Visakhapatnam, Bay of Bengal	8.7	2.1	ND	0.7	1.6	4.9	25.7	0.4	Subrahmanyam and Ananthalakshmi Kumari (1990)[45]
Kalpakkam coastal waters, Bay of Bengal	15.6	5.8	4.97	ND	22.7	56.9	53.1	2.9	Selvaraj (1999)[46]
Coastal waters, Gulf of Mannar	8.8	9.2	2.84	ND	3.1	8.9	15.3	1.8	Jonathan (1995)[47]

Vellar-Coleroon Estuary

The Vellar-Coleroon Estuarine complex is located in the southeast coast of India. Metals such as cadmium, cobalt, chromium, zinc and lead have been found in commercially important fishes, crabs and shrimps. Recently, the pattern of accumulation of heavy metal in the tissues of hermit crab *Clibanarius longitarsus*[48] was found to contain high concentrations of Cu and Zn in specific tissues such as the hepatopancreas. Increased uptake of metals by tissues was recorded with increase in dosage of metals.

Poompuhar

Poompuhar in south east coast of India was severely affected during 26th December 2004 tsunami showed high values of Zn, Cu, Fe, Mn, Co, Pb, Cd and Ni in water and in biota (*Mugil Cephalus*) after the tsunami compared with the levels before the tsunami In the case of sediments, higher values of Zinc and Copper were seen in samples taken post-tsunami whereas in the case of Iron and Manganese, the post-tsunami values were lower.

Muthupet Mangroves

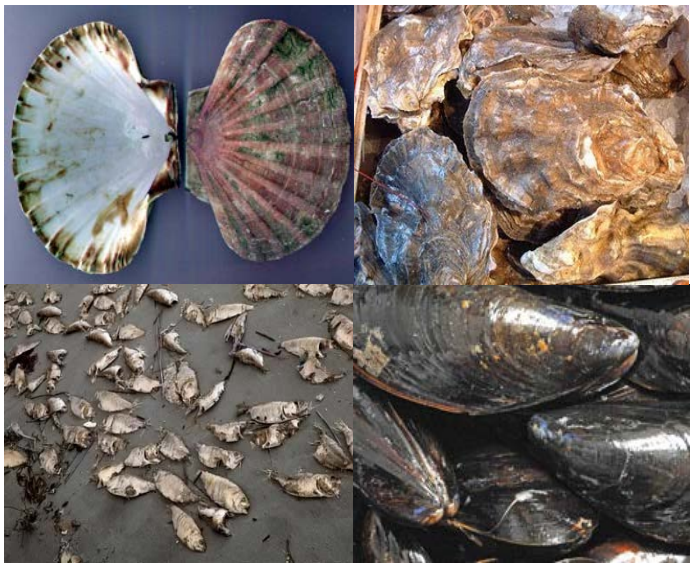
Heavy Metal Pollution in Reef Corals of Tuticorin Coast, Southeast Coast of India was investigated for the metal pollution in the skeletons of selected coral species like *Acropora formosa, Montipora digitata* and *Porites andrewsi* from the Tuticorin Coast, one of the least studied areas in the Bay of Bengal[49]. Relating heavy metal concentrations to morphological features of skeletons, highest concentrations of all the metals (except Cu and Zn) were found in ramose or branching types of corals. Irrespective of their growth characteristics or patterns, all these species displayed higher concentrations of Pb, Ni, Mn, and Cd within the skeletal part. The Tuticorin coast is exposed to a larger degree of metal pollution (natural and anthropogenic) than even before, as a result of the increasing environmental contamination from sewage discharges, the misuse of agricultural chemicals and fertilizers, and top soil erosion. this suggests that corals are vulnerable to accumulation of high concentrations of heavy metals in their skeletons and therefore can serve as proxies to monitor environmental pollution. In the Mullipallam creek of Muthupet mangrove forests, sediments showed higher concentration of iron, zinc, copper, manganese, cadmium and mercury in sediments compared to water.

5.4 Shell Fish Poisoning in the Bay of Bengal

Blooms of certain phytoplankton release toxins into the seawater which are concentrated by filter feeders such as mussels and other shellfish. When such

contaminated shellfish are consumed by humans, there can be outbreaks of a variety of illnesses with varying degrees of severity. These include:

- Amnesic shellfish poisoning
- Diarrhetic shellfish poisoning
- Neurotoxic shellfish poisoning
- Paralytic shellfish poisoning



Biotoxins primarily target the nervous system, but can also result in potentially fatal acute respiratory distress and other chronic neurological and immunological illnesses. The danger of inadvertently consuming biotoxins is compounded by the fact that they are odour and tasteless and are unaffected by food preparation procedures. The illness Ciguatera is associated with consuming fish contaminated with toxins produced by phytoplankton. Algal bloom resulted in the hospitalization of 85 people and death of three persons due to the consumption of bloom-affected mussel *Meretrix casta* in Tamil Nadu[50]. Common blooming species in the coastal waters of India are *Trichodesmium spp* and *Noctiluca scintillans*. Fishes tend to avoid blooms of *Noctiluca spp.*, due to the high ammonia content in their vacuoles and so they are often not affected.

5.5 Micro-organisms in Bay of Bengal Coast of India

Sewage and untreated effluents contain a wide range of human enteric pathogens, which may pose a health hazard to the exposed human population when they are discharged into coastal waters. In recent past, human interference through urbanization and industrialization has had serious impacts on the microbial population of coastal waters of the Bay of Bengal. The distribution of micro organisms/ pathogens in various coastal regions of the Bay of Bengal are discussed in the following section from Orissa in the North to Tamil Nadu in the South.

5.5.1 Orissa

In Orissa coast Total Counts of pathogens were comparatively higher and increased in areas close to the coastal waters indicating riverine discharges contaminated with sewage. High TC population was recorded in Puri, Paradip and Mahanadi transects

compared to other transects. The Fecal Coliform (FC) population was very high in Puri due to the high population density and disposal of untreated municipal sewage. The presence of faecal coliforms in the off shore samples is attributed to contamination from fishing boats.[51]

Andhra Pradesh

A total of nine bacterial pathogens, viz., *E. coli, Shigella sp, Salmonella sp, Vibrio cholerae, Steptococcus fecalis, Proteus, Klebsiella, Enterobacter, and P. aeruginosa, protozoans such as Entamoeba histolytica, Naegleria sp.,Giardia intestinalis, and Cryptosporidium sp.,* and Helminthic ova of *Ascaris lumbricoides, Ancylostoma, and Trichiurus,* were identified in the coastal waters. The Total Viable Count (TVC) in coastal waters ranged from 360/ml to 4140/ml and maximum viable populations were noticed at R.K. beach of Visakhapatnam coast. TC counts varied between 3 and 3090/ml[52].

However, reports of *Vibrio* sp., are not uncommon in the Indian subcontinent. For instance, high densities of *Vibrio* sp. were reported from the inshore waters of the east coast and from the offshore waters of the west coast but a concomitant outbreak of cholera or gastroenteritis were not noticed. Even at Visakhapatnam, though the counts of Vibrio sp., were high, there was no report of increased occurrence of disease. In sediments, bacterial counts were relatively higher. TVC varied from 11,550 to 356,050 no/g. Nevertheless, pathogen densities were high only in the sub tidal sediments of Visakhapatnam Harbour and Bheemuinipatnam and in the intertidal sediments of R.K. Beach. In general, the beach waters in Visakhapatnam are heavily polluted with microbial pathogens.

Tamil Nadu

The total and faecal coliforms bacteria were detected mainly in the water samples from the fishing harbours, ports and beaches. Studies on coliforms in water and sediments from Chennai and Tutucorin fishing harbours showed high faecal coliform bacteria counts compared to other landing centers where there is no mixing of domestic sewage. *E. coli* levels were relatively low at fishing harbor where it varied from 0 to 45 MPN ml^{-1} in water and 0.3 to 25MPN g^{-1} in sand samples. The coastal waters of Thoothukudi region showed high numbers of *E. coli* than the rest of the parts of East coast. *E. coli* number is less in sediments when compared to surface water[53,54].

5.6 Summary

In summary, this chapter has examined the present state of marine pollution as indicated by studies reported in various published literature. Eutrophication or nutrient enrichment is clearly a problem because of the loading from both agricultural non point

sources and sewage. Low salinities due to the discharge of large quantities of freshwater from the numerous deltaic rivers along the coast lead to favourable conditions for sporadic algal blooms in the waters, mostly near the coast. A few of the algal blooms have been found to harmful, some result in episodes of poisoning among coastal populations that have consumed contaminated shellfish. Sewage pollution along the coast is also indicated by the higher microbial (coliform) counts in the coastal waters. Trace metals that are associated with anthropogenic sources have been found to contaminate sediments in areas where there are industrial clusters.

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CHAPTER 6: TRANS-BOUNDARY COASTAL POLLUTION ISSUES AND CONCERNS

6.1 Concerns

The BOBLME region includes a number of countries among which the largest in land area is India. Closest to India are Bangladesh which shares a border, and Sri Lanka which is separated from the Indian subcontinent by the Palk Straits. In general, the population density is high along the coast in the BOBLME countries and in recent times, there has been an upsurge in industrialization of coastal areas. Thus apart from human settlements which contribute sewage and other organic wastes, largely untreated, into the Bay, coastal aquaculture (mainly shrimp aquaculture), industries such as power plants and ship breaking, are major sources of land based pollution.

6.2 Examples of Transboundary Impacts

Transboundary effects are generally described as issues that two or more countries have in common and that are either likely to require collaborative interventions by the countries involved, or for which a single-country intervention would benefit the region as a whole. An earlier review of the Bay of Bengal Region identified three main land based pollution categories of transboundary significance: sewage, agriculture and industry [1].

The Bay receives large quantities of freshwater and sediment from the numerous rivers that drain the Indian subcontinent which have high influence on the surface coastal water dynamics. The Bay also receives large amounts of water due to episodic floods in both India and Bangladesh. Cyclonic activity also plays an important role in the mixing processes in the Bay. Floods carry sediments, nutrients and other wastes into the Bay during such episodes and can have adverse impacts. The assimilative capacity of the Bay is unknown and though it is believed that the anthropogenic impacts of the surrounding countries is mainly local, there is increasing evidence that certain activities have transboundary effects. In this short review, the transboundary impacts of activities in Bangladesh that can affect India and vice versa; and the transboundary impacts of activities in India that can affect Sri Lanka and vice versa, alone are looked at.

6.2.1 India - Bangladesh

The Ganga-Brahmaputra-Meghna system is the lifeline of a large transboundary population in India and Bangladesh. A large number of cities are located on the banks of the rivers which form the river system and it is likely that during the monsoons at least, the floodwaters will carry some of the wastes and contaminants

downstream. The Farakka Barrage built in 1975 diverted some of the water into another tributary within India but it also had the effect of reducing the water flow in Bangladesh resulting in salinity intrusion; a treaty was signed between Bangladesh and India in 1996 on sharing waters and this has helped improve the situation [2]. The busy ports of Kolkata in India and Mongla in Bangladesh are riverine ports and it is likely that port-related activities result in loading of a variety of pollutants into the Bay via the river systems that drain into the Bay of Bengal. Similarly, Chittagong is a busy seaport of Bangladesh. In addition, ship breaking activities in Bangladesh are mainly near Chittagong. These activities are performed without any EIA; and the absence of any monitoring has resulted in wastes from ship breaking being directly discharged into the marine ecosystem. The wastes include oil and oily substances, heavy metals and a variety of persistent organic pollutants [3,4]. The authors conclude that the coastal waters off Chittagong are highly polluted because of these activities and there are also indications of bioaccumulation of pollutants in marine biota. However, apart from localized studies, there is little information about transboundary pollution (in this case impact on India / Bangladesh) due to port related activities in this section of the Bay of Bengal.

Shrimp farming is extensively practiced in Bangladesh in the coastal areas and is a possible contributor to pollutants into the Bay. However, there do not appear to be specific case studies on this aspect. The expansion of shrimp farming in the Sunderbans area may be a potential cause for land based transboundary pollutants.

6.2.2 India –Sri Lanka

The north-western regions of Sri Lanka are separated from the Indian subcontinent by the Palk Straits and the Gulf of Mannar. Both are sensitive ecosystems and are well known for their fish potential. Sources of land based pollutants are mainly from settlements along the coast as the region does not have major industries and has only one port (Tuticorin). Apart from oil spills arising due to shipping / fishing boats, the pollution effects appear to be localized.

6.3 Regional Agreements

A number of regional cooperative actions based on multilateral agreements are in place, some with specific focus on management of the environment while others are part of regional agreements. Some of the most important regional actions are the South Asia Cooperative Environment Programme (SACEP), the South Asian Seas Programme (SASP), the South Asian Association for Regional Cooperation (SAARC) and the Bay of Bengal Intergovernmental Organization (BOBP-IGO).

The Ministry of Environment and Forests is the nodal Ministry in the Government of India for all Multilateral Environmental Agreements with the 'International Cooperation and Sustainable Development Division' being the nodal point within the Ministry to coordinate all international environmental cooperation and sustainable development issues, including SACEP and SAARC.

(1) SACEP : The South Asia Cooperative Environment Programme (SACEP) was formed in the late nineteen seventies as an initiative by the United Nations Environment Programme for the protection, preservation and management of the South Asian Environment. India is a member country of the SACEP.

(2) SASP: The South Asian Seas Programme was adopted in March 1995 and is one of 17 such programmes. It has the unqualified support of the region's five countries (Bangladesh, India, Maldives, Pakistan and Sri Lanka) with the SACEP serving as the Action Plan secretariat.

(3) SAARC: The South Asian Association for Regional Cooperation is an organization of South Asian Nations founded in December 1985. Since 1987, the Heads of State or Government of SAARC at successive Summits have reiterated the need to strengthen and intensify regional cooperation to preserve, protect and manage the diverse and fragile eco-systems of the region including the need to address the challenges posed by climate change and natural disasters. The SAARC Ministerial Statement on Cooperation in Environment ("Delhi Statement"), 2009 emphasized the need for collective action in environmental management including the need for effective planning and management of environmental protection systems, including environmental pollution, and conservation of aquatic and marine ecosystems. The Ministers agreed to accelerate consultations between the apex environmental management and pollution control agencies of the Member States ("apex group"), and directed that they develop a Regional Cooperation Plan on environmental management and pollution control.

6.4 Conclusions

With respect to sewage and coastal pollution, the transboundary impacts are likely to be localized. On the other hand, oil pollution and alien species brought by ballast water are of some importance. A Regional Oil and Chemical Spill Contingency Plan and associated MoU has been developed in association with the International Maritime Oganization for enhanced cooperation among five maritime countries of South Asia in the event of an oil spill [5]. Changes in the monsoon driven circulation patterns due to climate change as well as variation in freshwater discharge from the large rivers flowing into the Bay due to both anthropogenic interference and changes in the precipitation pattern could have an important impact in the transboundary movement of pollutants from land based sources that need to be examined in detail.

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CHAPTER 7: INTERNATIONAL INSTRUMENTS ADOPTED, CURRENT STATUS OF IMPLEMENTATION

7.1 Introduction

In this chapter the various international instruments adopted by India and their current status of implementation are examined. India has participated in all major conferences related to the environment. In fact, the preamble of the Environment (Protection) Act, 1986 refers to the first United Nations Conference on the Human Environment (UNCHE) as follows:

> "Whereas decisions were taken at the United Nations Conference on the Human Environment held at Stockholm in June, 1972, in which India participated, to take appropriate steps for the protection and improvement of human environment:
> And whereas it is considered necessary further to implement the decisions aforesaid in so far as they relate to the protection and improvement of environment and the prevention of hazards to human beings, other living creatures, plants and property;

7.2 Agenda 21 and Sustainable Development

Twenty years after the UNCHE, Agenda 21 was released at the 1992 United Nations Conference on Environment and Development (UNCED, also known as Rio Summit). Agenda 21 is a blueprint for sustainable development and addresses the pressing problems of today and also aims at preparing the world for the challenges of the next century. It reflects a global consensus and political commitment at the highest level on development and environment co-operation [1]. In the context of the current report, specific mention must be made of Chapter 17 of the Agenda 21. This called for "the protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources".

Ten years after the UNCED, the World Summit on Sustainable Development (WSSD) was held at Johannesburg. A report was commissioned and coordinated by the Government of India in the Ministry of Environment and Forests and supported by the UNDP[2]. The following sections dealing with Chapter 17 - are taken largely from this report.

According to the report, a number of institutions are responsible for decision making with regard to different activities in coastal areas as summarized in the Table 7.1.

Table: 7.1: Institutions Responsible for Decision-making

Organization	Responsibilities
Ministry of Environment and Forests	Management of resources in the coastal waters, nodal ministry with major responsibility for protecting marine environment, includes implementation of legislative measures.
Department of Ocean Development	Scientific monitoring of the marine environment, Management of resources in the high seas
Ministry of Agriculture	Development of fisheries, aquaculture, fish processing
Ministry of Water Resources	Erosion
Ministry of Defence (Indian Coast Guard)	Pollution response measures, including oil pollution
Ministry of Surface Transport	Ports, shipping etc.
Ministry of Petroleum and Natural Gas	Offshore installations, coastal refineries, pipelines etc.
Ministry of Tourism	Tourism activities in coastal regions
Ministry of Mines	Mining activities in coastal regions

The major objectives of Agenda 21 with reference to the marine environment are

- the preserving of ecologically sensitive areas,
- developing and increasing the potential of marine living resources,
- ensuring effective monitoring and enforcement with respect to fishing activities,
- improving the living standards of coastal communities,
- maintaining the health of the marine environment and
- addressing issues of critical uncertainty and climate change.

In order to protect its marine environment, the Government of India, even before 1992, had initiated a number of programmes. These acquired a new significance post-1992. To meet the objectives of Agenda 21, continuous monitoring of ongoing projects, acquiring of new technology and implementation of already-existing policies are being actively carried out. Table 7.2 highlights the major policies and programmes adopted. The developments in policies post-Rio reflect responses to the changing international scenario, where there is a recognition that development needs to be attentive not only to the environment, but also to the people who have a stake in any such development.

Table 7.2: Highlights of Major Policies and Programmes

Year	Relevant Acts, programmes and policies	Salient features and Amendments
1897	Indian Fisheries Act	Offers protection to fisheries against explosives or dynamites
1908	Indian Ports Act	Enactment relating to ports and port charges. Provides for rules for the safety of shipping and conservation of ports
1978	Coast Guard Act	Provides levying of heavy penalties for the pollution of port waters In 1993, Coast Guard under Ministry of Defence, made directly responsible for combating marine pollution. National Oil Spill Disaster Contingency Plan, formulated in 1996, under Coast Guard Act lays down action to be taken in the event of oil spills
1958	Merchant Shipping Act	Control of pollution from ships and off-shore platforms
1972	Wildlife Protection Act	Offers protection to marine biota Creates conditions favourable for in situ conservation of fauna and flora. Amended in 1991 to prohibit fishing within the sanctuary area Gahirmatha, annual mass nesting place for Olive Ridley turtle, an endangered species, accorded the status of marine sanctuary in 1997. Amended in 2001 to include several species of fish, corals, sea cucumbers and sea shells in Schedule I and III Whale shark placed in schedule I
1974	Water (Prevention and Control of Pollution) Act	Control of pollution from land-based sources includes tidal waters, unlike many other countries and has jurisdiction upto 5 km in the sea
1976	Maritime Zones Act	Describes various zones such as territorial waters, EEZ, Continental shelf etc.
1978	Marine fishing Regulation Act	A model act, which provides guidelines to the maritime states to enact laws for protection to marine fisheries by regulating fishing in the territorial waters The measures include: regulation of mesh size and gear, reservation of zones for various fishing sectors and also declaration of closed seasons. Laws framed and amended from time to time by different maritime states Coastal states ban fishing during closed season Different closure period for different states
1980	Forest Conservation Act	Protection to marine biodiversity
1982	Coastal Pollution	Started in 1982 by CPCB

Year	Relevant Acts, programmes and policies	Salient features and Amendments
	Control Series (COPOCS programme)	Aims at assessing the pollution status of coastal waters
1986	Environment Protection Act (EPA)	Under this, the Coastal Regulation Zone 1991 has been notified. Standards for discharging effluents are listed
1991 (under EPA, 1986)	Coastal Regulation Zone Notification	Regulations on various activities in coastal zone. Classifies coastal zone into four categories specifying activities permitted and prohibited in each category Offers protection to backwaters and estuaries. Aquaculture was allowed as foreshore activity. The Supreme Court in 1996 banned all the aquaculture activities, except traditional and modified traditional, in the coastal zone up to 500m in most places. Aquaculture Authority was formed
1991	Deep Sea Fishing Policy	Allows foreign fishing vessels into Indian waters beyond 12 nautical miles. Protests from local fishermen Charter and leasing operations of foreign trawlers suspended in 1997 No granting of new licences to joint venture companies operating in the EEZ Deep Sea Fishing Policy, 1991 practically scrapped in 1997
1991	Coastal Ocean Monitoring and Prediction systems (COMAPS Project)	Being implemented from 1991 onwards Assesses the health of coastal waters and facilitates management of pollution-related issues Programme was restructured and modified in 2000-01 to include pollution monitoring; liaison, regulation and legislation; and consultancy services
1995	National Environmental Tribunal Act	This has been created to award compensation for damages to persons, property and the environment arising from any activity involving hazardous substances
1995	UNCLOS	India ratified the UN Convention on the Law of the Sea in 1995. The Department of Ocean Development is the nodal agency for implementation of the provisions of UNCLOS
1996	Coastal Zone Management Plans (CZMPs)	Supreme Court Intervention that all the Coastal states prepare their CZMPs by 1996
1997	National Environment	Addresses appeals with respect to restrictions of areas in which classes of industries etc. are carried

Year	Relevant Acts, programmes and policies	Salient features and Amendments
	Appellate Authority Act	out or prescribed subject to certain safeguards under the EPA The objective is to bring in transparency and accountability and to ensure the smooth and expeditious implementation of developmental schemes and projects The Tribunal has become defunct and the Act repealed upon the enactment of the National Green Tribunal Bill 2009
1998	Turtle Exclusion Device (TED) mandatory in Orissa	Orissa High Court passed judgment in 1998 that all fishing trawlers be equipped with TED
1998	Integrated Coastal and Marine Area Management (ICMAM Project)	Aims at integrated management of coastal and marine areas. Model plans for Chennai, Goa and Gulf of Kutch being prepared
Ninth Plan	DOD programme to assess living resources beyond 70 m depth	Major objectives were to have reliable and realistic information on the potential of marine living resources in the Indian EEZ for sustainable development and management and to augment sea food production and thereby the income of the coastal fishing community and the fishing industry. Initiated during the Ninth Five-year Plan for better understanding of the resources of the Indian EEZ, since the region upto 50–70 m depth is exploited almost to the maximum sustainable levels.
2000	The Biodiversity Bill	With an aim to protect and conserve biodiversity and sustainable use of its components the Biodiversity Bill is being placed in Parliament

The Department of Ocean Development (DOD) was established in 1981, with an aim to implementing programmes for sustainable development of the Indian Ocean. DOD formulated the first Ocean Policy Statement (OPS) of the country, which sets out the basic principles through which the development of ocean resources is to be carried out. The OPS lays emphasis on sustainable exploitation of living and non-living resources and protection, preservation and conservation of coastal and marine environment. India is the first country to adopt such a policy. Projects introduced by the Department of Ocean Development such as the Integrated Coastal and Marine Area Management (ICMAM: www.icmam.gov.in) aim at integrated management of coastal and marine areas. The DOD is currently under the Ministry of Earth Sciences. To promote specialization in marine sciences in different universities, the Department formulated a scheme for establishing Ocean Science and Technology

Cells (OSTC) in consultation with universities engaged in Marine Science research. So far eight OSTCs have been established.

In the years subsequent to the WSSD 2002 when the last update on Agenda 21 activities was made, additional activities have been carried out and some of the important ones are summarized in the Table 7.3.

Table 7.3: Updated Activities

2002	The Biological Diversity Act, 2002	The Act aims at the conservation of biological resources and associated knowledge as well as facilitating access to them in a sustainable manner and through a just process For purposes of implementing the objects of the Act it establishes the National Biodiversity Authority in Chennai.
2004	Comprehensive Marine Fishing Policy	The policy objectives are: (1) to augment marine fish production of the country up to the sustainable level in a responsible manner so as to boost export of sea food from the country and also to increase per capita fish protein intake of the masses, (2) to ensure socio-economic security of the artisanal fishermen whose livelihood solely depends on this vocation. (3) to ensure sustainable development of marine fisheries with due concern for ecological integrity and bio–diversity.
2005	The Disaster Management Act	Enacted for establishing requisite institutional mechanisms for drawing up and monitoring the implementation of disaster management plans, ensuring measures by various wings of the government for prevention and mitigating the effects of disasters, and for undertaking a holistic, co-ordinated, and prompt response to any disaster situation. Established the National Disaster Management Authority (NDMA) in New Delhi
2005	Coastal Aquaculture Authority Act	Establishment of the Coastal Aquaculture Authority for regulating the activities connected with coastal aquaculture in coastal areas and matters connected therewith or incidental thereto.

2006	National Environment Policy	The dominant theme of this policy is that while conservation of environmental resources is necessary to secure livelihoods and well-being of all, the most secure basis for conservation is to ensure that people dependent on particular resources obtain better livelihoods from the fact of conservation, than from degradation of the resource
2006	EIA Notification, updated	Environmental clearance mandatory for the development activities listed in its schedule.
2008	Mangroves for the Future	India is participating in the IUCN MFF initiative, under which it has prepared a national strategy and action plan. Six small grants and four large grants programmes have been envisaged. A national coordination body is also in place. India hosted the 4th Regional Steering Committee meeting in 2008.
2007-12	Eleventh Plan	Environment and Climate Change: Calls to integrate development planning and environmental concerns, providing the use of economic instruments based on the polluter pays principle, supplemented by command and control policies where these are more appropriate. Focus on river cleaning and the activity of the "Water Quality Assessment Authority (WQAA)" constituted in June 2001. Disaster Management: Paradigm shift to preparedness; Various schemes, such as The National Cyclone Risk Mitigation Project
2009	Constitution of 'National Ganga River Basin Authority'	For effective abatement of pollution of the river Ganga in keeping with sustainable development needs.
2009	The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976	Extra-ordinary Gazette Notification No. 736, dated 11 May 2009, on baseline system in India, and notifying the internal waters of India.

2009	DRAFT: The Marine Fisheries (Regulation and Management) Act, 2009	Introduced as a Bill in Parliament. Under discussion.
2009	LOICZ	LOICZ South Asia Node at Institute for Ocean Management, Anna University Chennai
2010	Hazard Line Mapping	Memorandum of Understanding has been signed for the mapping and delineation of the hazard line along India's coast, between the Ministry of Environment and Forests and the Survey of India (Department of Science & Technology) [3].
2010	WB ICZM Project[4]	1. National ICZM capacity-building at a total investment of about which will cover (i) mapping, delineation and demarcation of the hazard lines and delineation of the coastal sediment cells along the mainland coast of India; (ii) mapping, delineation and demarcation of environmentally-sensitive areas that require protection; (iii) establishment of a National Centre for Sustainable Coastal Management at Anna University, Chennai; and (iv) a nation-wide training programme for coastal zone management. 2. ICZM activities along the Gulf of Kachchh and in Jamnagar District in Gujarat 3. ICZM and wetland conservation activities in two stretches of the Orissa coast (i) Gopalpur-Chilika; and (ii) Paradip-Dhamra 4. ICZM activities in Sunderban, Haldia and Digha-Shankarpur regions of West Bengal
2010	Ganga River Basin Management Plan [5]	A step in the Mission Clean Ganga which aims to ensure that no untreated sewage enters the River Ganga by the year 2020
2010	Capacity Building for Industrial Pollution Management (CBIPMP) [6]	CBIPMP project will aim to remediate ten highly polluted sites, two in Andhra Pradesh and eight in West Bengal on a pilot basis, develop a National Plan for rehabilitation of polluted sites and build human and technical capacity in selected Pollution Control Boards for undertaking environmentally sound

		remediation of polluted sites
2010	National Green Tribunal Act	The tribunal is a special fast-track court to handle the expeditious disposal of the cases pertaining to environmental issues.

UNCLOS

It took UNCLOS III nine years of discussions to adopt the United Nations Convention on the Law of the Sea on 30 April 1982. Thereafter this convention took twelve years to formally come into force on 16 November 1994. In 1976, consequent upon the UNCLOS III, held at Geneva in which India participated, Article 297 of the Constitution of India was amended and all lands, mineral and other things of value, underlying the ocean, within the territorial waters or the continental shelf or the EEZ as well as all other resources of the EEZ were vested with the Union of India. The Article also provided that the limits of the Maritime Zones of India shall be as such, as may be specified from time to time by or under any Law made by the Parliament. The Indian government put in place The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976 which was enacted in ratification of the UNCLOS III provisions. This is umbrella legislation on maritime matters. Subsequently the Maritime Zones of India (Regulation of Fishing by Foreign Vessels) Act, 1981 was enacted for regulation of fishing by foreign vessels.

The Department of Ocean Development is the nodal agency for implementation of the provisions of United Nations Convention of the Law of the Sea (UNCLOS), in India. UNCLOS establishes the framework and mechanisms for management of oceans. India ratified the Convention in June 1995. With coming into force of United Nations Convention on Law of the Sea, the institutions such as International Seabed Authority (ISBA) and Commission on the Limits of Continental Shelf (CLCS) came into existence.

Delineation of Outer Limits of Continental Shelf: According to the provisions of UNCLOS, the coastal State that intends to delineate the outer limits of the continental shelf beyond 200 nautical miles, is required to submit particulars of such limits along with the supporting scientific and technical data. India made a presentation to the Commission on the Limits of Continental Shelf (CLCS) on 16th August 2010 [7]. If the claims are accepted by CLCS India would be in a position to claim substantial area beyond the EEZ. National Centre for Antarctic and Ocean Research (NCAOR) at Goa, an autonomous body under the DOD, is coordinating this national endeavour with active co-operation and participation of all national institutions.

7.2 Global Programme of Action for the Protection of Marine Environment from land-based Activities (GPA), 1995

The Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA-LBA) was adopted by 108 Governments and the European Commission at an intergovernmental conference convened for this purpose in Washington, D.C., United States of America, from 23 October to 3 November 1995. The first IGR meeting was held in Montreal, Canada in 2001. The second IGR meeting was held in Beijing, China from 16 - 20 October 2006. India participated in both meetings. An Asian training workshop to further the implementation of the GPA-LBA was held at the national level in Chennai, India from 27 to 29 November, 2007. The objective of the Workshop was "To enhance the implementation and mainstreaming of the GPA at the national level, as requested by governments during the Second Intergovernmental Review Meeting of the GPA (IGR-2), held in Beijing in October 2006." The workshop identified a wide range of experiences in different aspects of mainstreaming across the South and South-East Asian regions. A key issue for all countries in the region including India was the multiplicity of organizations and levels of administration involved. The importance of involving a full range of stakeholders in mainstreaming processes beyond environmental agencies was agreed with a lead agency playing a pivotal role at least in the initial stages of mainstreaming.

7.3 Stockholm Convention on Persistent Organic Pollutants, 2001

The **Stockholm Convention on Persistent Organic Pollutants** is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically and accumulate in the fatty tissue of humans and wildlife. Exposure to Persistent Organic Pollutants (POPs) can lead to serious health effects including certain cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease and even diminished intelligence. Given their long range transport, no single Government acting alone can protect its citizens or its environment from POPs. In response, the Stockholm Convention, which was adopted in 2001 and entered into force 2004, requires Parties to take measures to eliminate or reduce the release of POPs into the environment. The Convention is administered by the United Nations Environment Programme and based in Geneva, Switzerland. The first 12 compounds covered under the Convention are Aldrin, Chlordane, Dieldrin, Endrin, Heptachlor, Hexachlorobenzene, Mirex, Toxaphene, Polychlorinated Biphenyls, DDT, PCDD (Dioxin) and PCDF (Furans).

India became a Party to the Stockholm Convention in January 2006. For India the primary sources of pesticide POPs include production, imports as well as stockpiles of obsolete pesticide stocks. Except for DDT that is restricted for use in vector

control, seven pesticide POPs listed in the Stockholm Convention are already banned for manufacture and use in India. The primary sources of dioxins and furans are high temperature combustion and high temperature manufacturing operations such as incinerators, metal smelting, pulp and paper production, among many others.

According to the Country Situation on POPs in India, the Ministry of Environment and Forests (MoEF), Government of India, is the focal point for POPs in India. The MoEF has established and will chair a Steering Committee comprising representatives of the Department of Chemicals and Petrochemicals, Ministry of Chemicals and Fertilizers, Ministry of Agriculture, Ministry of Health and Family Welfare, Ministry of External Affairs, Department of Industrial Policy and Promotion, National Institute of Occupational Health, Industrial Toxicological Research Centre and the Confederation of Indian Industry.

National Implementation Plan (NIPs): The first step was a Preliminary assessment of the sources and stocks of POPs. This activity was undertaken by the Ministry of Environment and Forest through Industrial Toxicology Research Centre (now, Indian Institute of Toxicology Research (IITR)) with the assistance of UNIDO under the Project Development Facility grant provided by GEF (Global Environment Facility). It was found that aldrin, dieldrin, endrin, chlordane, heptachlor and toxaphene are banned for manufacture, use, import and export in India. DDT is banned for agricultural use and its restricted use is permitted in public health sector for malaria control. Mirex and HCB have never been registered as Pesticides in India. PCBs have never been manufactured in India. Small quantities have been imported but exact figures are not available. PCBs are mainly used in transformers, capacitors. Unintended By-products like dioxins and furans are generated from municipal waste, burning of landfill sites, open burning of garbage. Capabilities to study Dioxins and Furans have just started in the country and need to be expanded.

At its fourth meeting held from 4 to 8 May 2009, the Conference of the Parties (COP), of the Stockholm Convention resolved to list nine additional chemicals as persistent organic pollutants. These are:

- Pesticides: chlordecone, alpha hexachlorocyclohexane, beta hexachlorocyclohexane, lindane, pentachlorobenzene;
- Industrial chemicals: hexabromobiphenyl, hexabromodiphenyl ether and heptabromodiphenyl ether, pentachlorobenzene, perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride, tetrabromodiphenyl ether and pentabromodiphenyl ether; and
- By-products: alpha hexachlorocyclohexane, beta hexachlorocyclohexane and pentachlorobenzene (also listed under pesticides).

New POPs are a cause of grave concern in India. Most of the emerging POPs continue to be manufactured and used extensively in the country. They have been detected in all parts of the environment, including bottled water and aerated drinks as shown in a study by the Centre for Science and Environment [8]. India's National Implementation Plan has not yet been transmitted to the POPs secretariat according to the POPs website.

7.4 IMO CONVENTIONS

India has signed/ratified some of the important IMO conventions especially those dealing with pollution from ships and safety at sea. These are mainly administered by the Directorate of Shipping (http://www.dgshipping.com/)

- **Pollution of sea**: The International Convention for the Prevention of Pollution from Ships (MARPOL) was adopted on 2 November 1973 at IMO and covered pollution by oil, chemicals, harmful substances in packaged form, sewage and garbage. The Protocol of 1978 relating to the 1973 International Convention for the Prevention of Pollution from Ships (1978 MARPOL Protocol) was adopted at a Conference on Tanker Safety and Pollution Prevention in February 1978 held in response to a spate of tanker accidents in 1976-1977. India is a signatory to MARPOL and has incorporated the principles set out in MARPOL in legislation. These are:

    - The Merchant Shipping Rules, 2010
    - Framing of Merchant Shipping (control of Pollution by Noxious Liquid Substance in Bulk) Rules, 2010. (MARPOL -Annex II)
    - Framing of Merchant Shipping (Prevention of Pollution by Harmful Substances carried by Sea in Packaged Form) Rules, 2010. (Annex-III)
    - Framing of Merchant Shipping (Prevention of Pollution by Sewage from ships) Rules, 2010. (Annex-IV)
    - Framing of Merchant Shipping (Prevention of Pollution by Garbage from Ships) Rules, 2010. (Annex-V)

- **Oil Pollution**
    - The Merchant shipping (Prevention of Pollution of the Sea by Oil) Rules, 1974. This is based on the International Convention for the Prevention of Pollution of the Sea by Oil, 1954
    - Merchant Shipping (Form of Certificate of Insurance for Civil Liability for Oil Pollution Damage) Rules, 1985. This is based on the International Convention on Civil Liability for Oil Pollution Damage, signed at Brussels on 29th November, 1969
    - Merchant Shipping (Levy of Oil Pollution Cess) Rules, 1988

- **Oil Spill Response**
  - International Convention on Oil Pollution Preparedness, Response and Co-operation, 1990: After the adoption of the OPRC convention by the IMO in 1990 with final Act and ten resolutions and promulgation of the Convention in 1995, India became one of the few countries that readily accepted the Convention.
  - The Indian Coast Guard is the national authority under the National Oil Spill Disaster Contingency Plan (NOSDCP) for coordination of response to oil spills in Indian waters. The maritime zone of India is divided into three regions: West, East, and Andaman & Nicobar. These regions are further divided into 11 districts. The regional commanders are responsible for combating oil spills in their respective areas of responsibility under the Regional Oil Spill Disaster Contingency Plans (ROS-DCP). There are three response centres - one in each region – with qualified response personnel and well-stocked inventory of response equipment.
  - Regional Contingency Plan sponsored by the UNEP for regional and bilateral agreement for South Asia, under the UN Clean Seas Programme is under finalisation. The countries that will be covered by bilateral agreement are Bangladesh, India, Maldives, Pakistan, and Sri Lanka. This Plan envisages mutual cross border assistance and movement of equipment and personnel to respond to oil spills in the seas across the region.

1 Preamble of Agenda 21. http://www.un.org/esa/dsd/agenda21/res_agenda21_01.shtml
2 Agenda 21, An Assessment. http://envfor.nic.in/divisions/ic/wssd/doc2/main.html
3 CCEA nod for Rs 1156 crore integrated coastal zone management project. 25 March 2010. http://moef.nic.in/downloads/public-information/iczm.pdf
4 CCEA nod for Rs 1156 crore integrated coastal zone management project. 25 March 2010. http://moef.nic.in/downloads/public-information/iczm.pdf
5 MoEF signs MoU with IIT consortium to prepare Ganga River Basin Management Plan. 6 July 2010. http://moef.nic.in/downloads/publicinformation/DOC20100706.pdf
6 India, World Bank sign two loan agreements for Coastal Zone Management and Remediation of Polluted Sites. 22 July 2010. http://moef.nic.in/downloads/public-information/World-Bank-Loans-Press-Brief.pdf
7 UNCLOS, Commission on the Limits of the Continental Shelf. Statement by the Chairperson of the Commission on the Limits of the Continental Shelf on the progress of work in the Commission. Twenty-sixth session New York, 2 August-3 September 2010. CLCS/68 dated 17 September 2010.
8 Narain, Sunita. 2003. The Pesticide is the point. Down to Earth, 15 August, 2003.

CHAPTER 8: POLICY, ECONOMIC INSTRUMENTS AND LEGAL MECHANISMS FOR POLLUTION CONTROL

8.1. Introduction: Legislation for Pollution Control

Freshwater is essential for a variety of activities and is obtained from surface and ground water sources. Water, after use for various purposes, is often discharged as wastewater. Wastewater contains pollutant loads of varying intensity depending on its origin and is usually discharged, untreated or partially treated, into receiving waters. The natural purification capacity of streams is frequently overwhelmed because of the quantity of wastewater discharged and hence problems of pollution result. In India, the problem of water pollution is addressed by different laws as well as various policies and action plans which are discussed here.

8.1.1. The Water (Prevention and Control of Pollution) Act, 1974 (amended 1988)

The Water Act, 1974 was enacted in 1974 to provide for the prevention and control of water pollution, and for the maintaining or restoring of wholesomeness of water in the country. The Act was amended in 1988. The Act defines "pollution" as “such contamination of water or such alteration of the physical, chemical or biological properties of water or such discharge of any sewage or trade effluent or of any other liquid, gaseous or solid substance into water (whether directly or indirectly) as may, or is likely to, create a nuisance or render such water harmful or injurious to public health or safety, or to domestic, commercial, industrial, agricultural or other legitimate uses, or to the life and health of animals or plants or of aquatic organisms”. It also defines that the stream (into which water is let into) includes rivers, water courses (even when dry), inland waters (natural and artificial), subterranean waters as well as sea or tidal waters to such extent or, as the case may be, to such point as the state government may, by notification in the Official Gazette, specify in this behalf. The Act is applicable up to 5 km into the sea.

The Act established Central and State Boards for Prevention and Control of Water Pollution. The State Boards have the power to develop comprehensive plans for preventing and controlling water pollution, training personnel in such activities, inspect sewage and trade effluents and treatment systems and grant consent for disposal of wastewater apart from laying down or modifying standards for wastewaters and tolerance limits for pollutants as well as doing research into related matters (Section 17).

The Act provides for a permit system to prevent and control water pollution by setting standards. Section 24 of the Act prohibits disposal of polluting matter into a stream and a person has to obtain consent from the Pollution Control Board before setting up operations, processes and activities that discharge wastewater (sewage or trade

effluent). The Act empowers a state board, upon 30 days notice to a polluter, to execute any work required under a consent order which has not been executed. The board may recover the expenses for such work from the polluters. The Act establishes criminal penalties of fines and imprisonment for non compliance with orders given. Section 33 empowers the Board to make application to Courts for restraining apprehended pollution of water in streams or wells or in any sewer or on any land or otherwise.

Section 33A was inserted when the Act was amended in 1988. It allows the state boards to issue orders to polluters including orders for closure of a polluting industry or cutting of water, electricity or other services. The 1988 amendment also allowed any person (not just the board) to proffer a complaint in the prescribed manner with regard to water pollution thus enabling citizens to bring action under the Act.

The Water (Prevention and Control of Pollution) Rules, 1975 deal in detail with the constitution and functioning of the Central Pollution Control Board as well as items such as rates for analysis of samples and forms for issuing notice. The Water (Prevention and Control of Pollution) Cess Act was enacted in 1977, to provide for the levy and collection of a cess on water consumed by persons operating and carrying on certain types of industrial activities. This cess is collected with a view to augment the resources of the Central Board and the State Boards for the prevention and control of water pollution constituted under the Water (Prevention and Control of Pollution) Act, 1974. The Act was last amended in 2003. The Water (Prevention and Control of Pollution) Cess Rules, 1978 deal with cess to be paid by water consumers. This also includes charges for sewerage and wastewater treatment where applicable as this is calculated based on water consumption.

8.1.2. The Environment (Protection) Act

The Environment (Protection) Act was enacted in 1986 with the objective of providing for the protection and improvement of the environment. 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 Act was last amended in 1991.

The EPA 1986 is an umbrella legislation designed to provide a framework for the Central Government coordination of activities of various central and state boards established under previous laws. It is an enabling law as it designates power to the executive to enable bureaucrats to frame necessary rules and regulations. The Central Government is provided with the power to take measures as deemed necessary for the protection and improving the quality of the environment and preventing, controlling and abating environmental pollution (3(1)). Measures

including prescribing standards for emission or discharge of pollutants, restriction of areas of operation of industries or processes, procedures for preventing environmental pollution etc. come under this section.

As in the case of the Water (Prevention and Control of Pollution) Act, criminal penalties of fines and/or imprisonment for contravening the provisions of the Act and Rules have been specified.

The Environment (Protection) Rules specify standards for emission or discharge of environmental pollutants from industries, operations or processes (Section 3). It also permits state boards to specify more stringent standards for relevant industries with respect to specific industry or locations. Section 5 describes Prohibitions and restrictions on the location of industries and the carrying on processes and operations in different areas which include the likely emission or discharge of environmental pollutants from an industry, process or operation proposed to be prohibited or restricted. In case of discharge of environmental pollutant in excess of the prescribed standards occurs or is apprehended to occur due to any accident or other unforeseen act or event, specific authorities such as the officer-in-charge of emergency or disaster relief operation in a district are to be notified.

Notifications and other instruments: The powers conferred by the EPA 1986 are followed under various heads of which the most relevant for water pollution are the following:

CRZ: The Coastal Regulation Zone Notification (CRZ) 1991 classified coastal stretches within 500m from the high tide line into four categories, restricting activities especially the setting up of industries in this zone. Specifically, setting up and expansion of units/mechanism for disposal of waste and effluents are prohibited except facilities required for discharging treated effluents into the water course with approval under the Water (Prevention and Control of Pollution) Act, 1974 and except for storm water drains. Also it is prohibited to discharge untreated wastes and effluents from industries, cities or towns and other human settlements in this area. The CRZ Notification also set up State/Union Territory Coastal Zone Management Authority. Activities / Industries in the CRZ area require detailed EIA reports apart from CRZ clearance from the State Coastal Management Authority (SCZMA) for environmental clearance.

The CRZ 1991 was been updated in January 2011. The CRZ 2011 is essentially for activities along the coast of mainland India (and 4 of the large islands in the Andaman and Nicobar group) whereas the new Island Protection Zone 2011 (IPZ 2011), regulates the activities in the island territories of India (Andaman & Nicobar in

the Bay of Bengal and the Lakshadweep in the Arabian Sea). In the CRZ 2011, the coastal regulation zone includes the following:

- 500 m landward from the High Tide Line (HTL)
- 12 nautical miles seaward from the Low Tide Line (LTL)
- The area between the HTL and the LTL
- Land area between HTL to 100 mts or width of the creek whichever is less on the landward side along the tidal influenced water bodies that are connected to the sea and the distance upto which development along such tidal influenced water bodies is to be regulated shall be governed by the distance upto which the tidal effects are experienced which shall be determined based on salinity concentration of 5 parts per thousand (ppt) measured during the driest period of the year

As in the CRZ 1991 notification, the Coastal Regulation Zone is classified into four:

1. CRZ-I: Ecologically sensitive areas and the geomorphological features which play a role in the maintaining the integrity of the coast as well as the area between HTL and LTL
2. CRZ -II: The areas that have been developed upto or close to the shoreline.
3. CRZ-III: Areas that are relatively undisturbed and those do not belong to either CRZ-I or II
4. CRZ-IV: A. the water area from the Low Tide Line to twelve nautical miles on the seaward side; and B. the water area of the tidal influenced water body from the mouth of the water body at the sea upto the influence of tide which is measured as five parts per thousand during the driest season of the year.

And additional class though not listed as CRZ – V is 'Areas requiring special consideration for the purpose of protecting the critical coastal environment and difficulties faced by local communities'.

With specific reference to this report, the important point to be seen here is with regard to CRZ-IV which is that:

In CRZ-IV areas,-
The activities impugning on the sea and tidal influenced water bodies will be regulated except for traditional fishing and related activities undertaken by local communities as follows:-
(a)No untreated sewage, effluents, ballast water, ship washes, fly ash or solid waste from all activities including from aquaculture operations shall be let off or dumped. A comprehensive plan for treatment of sewage generating from the coastal towns and cities shall be formulated within a period of one year in consultation with stakeholders including traditional coastal communities, traditional fisherfolk and implemented;

(b) Pollution from oil and gas exploration and drilling, mining, boat house and shipping;

This makes it clear that there is awareness about the problem of pollution due to sewage especially from the large towns and cities along the coast and this is to be addressed. Similarly, the problem of pollution of the marine environment due to discharge of wastes during offshore activities is also to be controlled.

EIA 2006: The Environmental Impact Assessment Notification 2006 makes environmental clearance mandatory for the development activities listed in its schedule. For obtaining environmental clearance, information on pollution load due to the activity, the methods of wastewater disposal and detailed environmental management plan including plan for monitoring of specified parameters in relation to the aquatic environment have to be provided in detail as part of the EIA report. The categorization of projects in the notification, into A and B, has been done based on "spatial extent of potential impacts on human health and natural and manmade resources." Category A projects require clearance by the MoEF while Category B projects are to be cleared by the State Environment Impact Assessment Authority (SEIAA).

Constitution of 'National Ganga River Basin Authority'[1]: By a notification on 20th February 2009, the NGRBA was constituted with the power to take all such measures and discharge functions as it deems necessary or expedient for effective abatement of pollution of the river Ganga in keeping with sustainable development needs. A Memorandum of Agreement (MoA) has been signed by the Ministry of Environment & Forests (MoEF) with a consortium of seven Indian Institutes of Technology (IITs) for the development of Ganga River Basin Management Plan (GRBMP). The Plan will outline comprehensive measures for restoration of the Ganga, with due regard to the issue of competing water uses in the river basin [2].

Other relevant rules under EPA 1986: The Recycled Plastics Manufacture and Usage Rules, 1999; Municipal Solid Wastes (Management and Handling) Rules, 2000; Ozone Depleting Substances (Regulation) Rules, 2000; The Prevention and Control of Pollution (Uniform Consent Procedure) Rules, 1999

8.1.3 The Coast Guard Act, 1978

This requires the taking of such measures as are necessary to preserve and protect the maritime environment and to prevent and control marine pollution (Section 14-1c).

8.1.4 The Territorial Waters, Continental Shelf, Exclusive Economic Zone and other Maritime Zones Act, 1976:

Under Section 15 “Power to make rules” is included power to make rule for “preservation and protection of the marine environment and prevention and control of marine pollution for the purposes of this Act”.

8.1.5 Coastal Aquaculture Authority Act, 2005

This provides for the establishment of the Coastal Aquaculture Authority for regulating the activities connected with coastal aquaculture in coastal areas and matters connected therewith or incidental thereto. The Act mandates the Central Government to take all such measures as it deems necessary or expedient for regulation of coastal aquaculture by prescribing guidelines, to ensure that coastal aquaculture does not cause any detriment to the coastal environment and the concept of responsible coastal aquaculture contained in the guidelines shall be followed in regulating coastal aquaculture activities to protect the livelihood of various sections of people living in the coastal areas.

Coastal Aquaculture Authority Rules, 2005: Discharge of wastewater has to follow certain norms as given in Section 4(1). Specifically, no wastewater is to be released out of a hatchery without chlorination and dechlorination to prevent escape of larvae into the receiving waters and ETPs have to be designed to include this system.

8.1.6 National Environmental Appellate Authority Act, 1997

This Act provides for the establishment of a National Environment Appellate Authority to hear appeals with respect to restrictions of areas in which industries, operations or process or class of industries, operations and process it, shall be carried out subject to certain safeguards under the Environment (Protection) Act, 1986.

8.1.7 The National Green Tribunal

This was established on 18.10.2010 under the National Green Tribunal Act 2010 for effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for such relevant matters.

8.1.8 The Indian Ports Act, 1908

This is an Act to consolidate the Enactments relating to Ports and Port-charges. Section 21 of this Act reads as follows:

Improperly discharging ballast

(1) No ballast or rubbish, and no other thing likely to form a bank or shoal or to be detrimental to navigation, shall, without lawful excuse, be cast or thrown into any such port or into or upon any place on shore from which the same is liable to be washed into any such port, either by ordinary or high tides, or by storms or land-floods [and no oil or water mixed with oil shall be discharged in or into any such port, to which any rules made under clause (ee) of sub-section (1) of section 6 apply, otherwise than in accordance with such rules].

(2) Any person who by himself or another so casts or throws any ballast or rubbish or any such other thing [or so discharges any oil or water mixed with oil], and the master of any vessel from which the same is so cast, [thrown or discharged], shall be punishable with fine which may extend to five hundred rupees, and shall pay any reasonable expenses which may be incurred in removing the same.

(3) If after receiving notice from the conservator of the port to desist from so casting or throwing any ballast or rubbish or such other thing [or from so discharging any oil or water mixed with oil], any master continues so to cast, [throw or discharge the same], he shall also be liable to simple imprisonment for a term which may extend to two months.

(4) Nothing in this section applies to any case in which the ballast or rubbish or such other thing is cast or thrown into [or the oil or water mixed with oil is discharged in or into] any such port with the consent in writing of the conservator, or within any limits within which such act may be authorised by the [Government].

8.1.9 The Merchant Shipping Act, 1958 (44 of 1958)

The Merchant shipping (Prevention of Pollution of the Sea by Oil) Rules, 1974 were formulated under the above act and say that oil or oily discharge by Indian ships is prohibited in the Prohibited Zone (all over the world). Reports of discharge have to be filed in the format given in the Annexure to the Rules. For Bay of Bengal, the prohibited zone is given as follows:

(ii) **The Bay of Bengal Coastal Zone**

The Bay of Bengal Coastal zone shall comprise the sea areas between the nearest land and a line drawn between the following positions:

Latitude	*Longitude*
10º 15 º north	80 º 50 º east;
14 º 30 º north	81 º 38 º east;
20 º 20 º north	88 º 10 º east;
20 º 20 º north	89 º east;

8.2 Water Quality Standards

The term ‘standard’ applies to any definite principle or measure established by an authority. When water quality is referred to, it usually refers to drinking water quality. Standards are also prescribed for receiving water quality to ensure that the load on the receiving waters is not greater than their assimilative capacity.

8.2.1 Water quality criteria for freshwater

In India, CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria. Based on the concept of ‘designated best use’, CPCB has classified all waterbodies in India into five “designated best use” [3]. This classification helps the water quality managers and planners to set water quality targets and design suitable restoration programs for various water bodies. The five classes and the corresponding primary water quality criteria are given in Table 8.1.

Table 8.1: Designated Best Uses of Water [4]

Designated Best Use	Class	Criteria
Drinking Water Source without conventional treatment but after disinfection	A	1.Total Coliforms Organism MPN/100ml shall be 50 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 6mg/l or more 4. Biochemical Oxygen Demand 5 days 20 °C, 2mg/l or less
Outdoor bathing (Organised)	B	1.Total Coliforms Organism MPN/100ml shall be 500 or less 2. pH between 6.5 and 8.5 3. Dissolved Oxygen 5mg/l or more

Designated Best Use	Class	Criteria
		4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/l or less
Drinking water source after conventional treatment and disinfection	C	1. Total Coliforms Organism MPN/100ml shall be 5000 or less 2. pH between 6 and 9 3. Dissolved Oxygen 4mg/l or more 4. Biochemical Oxygen Demand 5 days 20 °C, 3mg/l or less
Propagation of Wild life and Fisheries	D	1. pH between 6.5 and 8.5 2. Dissolved Oxygen 4mg/l or more 3. Free Ammonia (as N) as 1.2 mg/l or less 4. Biochemical Oxygen Demand 5 days 20 °C, 2mg/l or less
Irrigation, Industrial Cooling, Controlled Waste disposal	E	1. pH between 6.0 and 8.5 2. Electrical Conductivity at 25 °C micro mhos/cm, maximum 2250 3. Sodium absorption Ratio Max. 26 4. Boron Max. 2mg/l
	Below-E	Not meeting any of the A, B, C, D & E criteria

In addition, the Bureau of Indian Standards has also recommended water quality parameters for different uses in the standard IS 2296:1992 (Table 8.2)

Table 8.2: Water Quality Standards in India (Source IS 2296:1992)

Characteristics	Designated Best Use				
	A	B	C	D	E
Dissolved Oxygen (DO)mg/l, min	6	5	4	4	-
Biochemical Oxygen demand (BOD)mg/l, max	2	3	3	-	-
Total coliform organisms MPN/100ml, max	50	500	5,000	-	-
pH value	6.5-8.5	6.5-8.5	6.0-9.0	6.5-8.5	6.0-8.5
Colour, Hazen units, max.	10	300	300	-	-
Odour	Un-objectionable			-	-
Taste	Tasteless	-	-	-	-
Total dissolved solids, mg/l, max.	500	-	1,500	-	2,100
Total hardness (as $CaCO_3$), mg/l, max.	200	-	-	-	-
Calcium hardness (as $CaCO_3$), mg/l, max.	200	-	-	-	-

Characteristics	Designated Best Use				
	A	B	C	D	E
Magnesium hardness (as $CaCO_3$), mg/l, max.	200	-	-	-	-
Copper (as Cu), mg/l, max.	1.5	-	1.5	-	-
Iron (as Fe), mg/l, max.	0.3	-	0.5	-	-
Manganese (as Mn), mg/l, max.	0.5	-	-	-	-
Chlorides (as Cu), mg/l, max.	250	-	600	-	600
Sulphates (as SO_4), mg/l, max.	400	-	400	-	1,000
Nitrates (as NO_3), mg/l, max.	20	-	50	-	-
Fluorides (as F), mg/l, max.	1.5	1.5	1.5	-	-
Phenolic compounds (as C_2H_5OH), mg/l, max.	0.002	0.005	0.005	-	-
Mercury (as Hg), mg/l, max.	0.001	-	-	-	-
Cadmium (as Cd), mg/l, max.	0.01	-	0.01	-	-
Selenium (as Se), mg/l, max.	0.01	-	0.05	-	-
Arsenic (as As), mg/l, max.	0.05	0.2	0.2	-	-
Cyanide (as CN^-), mg/l, max.	0.05	0.05	0.05	-	-
Lead (as Pb), mg/l, max.	0.1	-	0.1	-	-
Zinc (as Zn), mg/l, max.	15	-	15	-	-
Chromium (as Cr^{6+}), mg/l, max.	0.05	-	0.05	-	-
Anionic detergents (as MBAS), mg/l, max.	0.2	1	1	-	-
Barium (as Ba), mg/l, max.	1	-	-	-	-
Free Ammonia (as N), mg/l, max	-	-	-	1.2	-
Electrical conductivity, micromhos/cm, max	-	-	-	-	2,250
Sodium absorption ratio, max	-	-	-	-	26
Boron, mg/l, max	-	-	-	-	2

8.2.2 Water quality criteria for coastal waters

In a coastal segment marine water is subjected to several types of uses. Depending of the types of uses and activities, water quality criteria have been specified to determine its suitability for particular purpose in the Environment (Protection) (Second Amendment) Rules, 1998. Among the various types of uses there is one use that demands highest level of water quality/purity and that is termed as “designated best use” in that stretch of the coastal segment. These are given in Table 8.3.

Table 8.3: Designated Best Use-Coastal Segments

Class	Designated best use
SW-I	Salt pans, Shell fishing, Mariculture and Ecologically Sensitive Zone.
SW-II	Bathing, Contact Water Sports and Commercial fishing.
SW-III	Industrial cooling, Recreation (non-contact) and Aesthetics.
SW-IV	Harbour.
SW-V	Navigation and Controlled Waste Disposal.

Based on this primary water quality criteria have been specified for the following five designated best uses as given in the Tables 8.4 to 8.8 [5].

Table 8.4: Primary Water Quality Criteria for Class SW-I Waters (For Salt pans, Shell fishing, Mariculture and Ecologically Sensitive Zone)

S.No.	Parameter	Standards	Rationale/Remarks
1	2	3	4
1.	pH range	6.5-8.5	General broad range, conducive for propagation of aquatic lives, is given. Value largely depended upon soil-water interaction.
2.	Dissolved Oxygen	5.0 mg/l or 60 percent saturation value, whichever is higher	Not less than 3.5 mg/l at any time of the year for protection of aquatic lives.
3.	Colour and Odour	No noticeable colour or offensive odour	Specially caused by chemical compounds like creosols, phenols, naptha, phyridine, benzene, toluene etc. causing visible colouration of salt crystal and tainting of fish flesh.
4.	Floating Matters	Nothing obnoxious or detrimental for use purpose.	Surfactants should not exceed and upper limit of 1.0 mg/l and the concentration not to cause any visible foam.
5.	Suspended Solids	None from sewage or industrial waste origin	Settleable inert matters not in such concentration that would impair any usages specially assigned to this class.
6.	Oil and Grease (including Petroleum Products)	0.1 mg/l	Concentration should not exceed 0.1 mg/l as because it has effect on fish eggs and larvae.

S.No.	Parameter	Standards	Rationale/Remarks
t7.	Heavy Metals: Mercury (as Hg) Lead (as Pb) Cadmium (as Cd)	0.01 mg/l 0.01 mg/l 0.01 mg/l	Values depend on: (i) Concentration in salt, fish and shell fish. (ii) Average per capita consumption per day. (iii) Minimum ingestion rate that induces symptoms of resulting diseases.

Note: SW-I is desirable to be safe and relatively free from hazardous chemicals like pesticides, heavy metals and radionuclide concentrations. Their combined (synergistic or antagonistic) effects on health and aquatic lives are not yet clearly known. These chemicals undergo bio-accumulation, magnification and transfer to human and other animals through food chain. In areas where fisheries, salt pans are the governing considerations, and presence of such chemicals apprehended/reported, bioassay test should be performed following appropriate methods for purpose of setting case-specific limits.

Table 8.5: Primary Water Quality Criteria for Class SW-II Waters (for bathing, contact water sports and commercial fishing)

S.No.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-8.5	Range does not cause skin or eye irritation and is also conducive for propagation of aquatic lives.
2.	Dissolved Oxygen	4.0 mg/l or 50 percent saturation value whichever is higher	No less than 3.5 mg/l at anytime for protection of aquatic lives.
3.	Colour and Odour	No noticeable colour or offensive odour	Specially caused by chemical compounds like creosols phenols, naptha, benzene pyridine, toluene etc. causing visible colouration of water and tainting of and odour in fish flesh.
4.	Floating Matters	Nothing obnoxious or detrimental for use purpose.	None in concentration that would impair usages specially assigned to this class.
5.	Turbidity	30 NTU (NepheloTurbidity Unit)	Measured at 0.9 depth.
6.	Fecal Coliform	100/100 (MPN)	The average value not exceeding 200/100 ml. in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
7.	Biochemical Oxygen Demand (BOD) (3 days at 27°C)	3 mg/l	Restricted for bathing (aesthetic quality of water). Also prescribed by IS:2296-1974.

Table 8.6: Primary Water Quality Criteria for Class SW-III Waters (for industrial cooling, recreation (non-contact) and aesthetics)

S.No.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-8.5	The range is conducive for propagation of aquatic species and restoring natural system.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value whichever is higher.	To protect aquatic lives.
3.	Colour and Odour	No noticeable colour or offensive odour	None in such concentration that would impair usages specifically assigned to this class.
4.	Floating Matters	No visible, obnoxious floating debris, oil slick, scum.	As in (3) above.
5.	Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
6.	Turbidity	30 NTU	Reasonably clear water for Recreation, Aesthetic appreciation and Industrial cooling purposes.
*7.	Dissolved Iron (as Fe)	0.5 mg/l or less	It is desirable to have the collective concentration of dissolved Fe and Mn less or equal to 0.5 mg/l to avoid scaling effect.
*8.	Dissolved Manganese (as Mn)	0.5 mg/l or less	

* Standards included exclusively for Industrial Cooling purpose. Other parameters remain the same.

Table 8.7: Primary Water Quality Criteria for Class SW-IV Waters (for harbour waters)

S.No.	Parameter	Standards	Rationale/Remarks
1.	pH range	6.5-9.0	To minimize corrosive and scaling effect.
2.	Dissolved Oxygen	3.0 mg/l or 40 percent saturation value whichever is higher.	Considering bio-degradation of oil and inhibition to oxygen production through photosynthesis.
3.	Colour and Odour	No visible colour or odour	None from reactive chemicals which may corrode paints/metallic surfaces.

S.No.	Parameter	Standards	Rationale/Remarks
4.	Floating materials, Oil, grease and scum (including Petroleum products)	10 mg/l	Floating matter should be free from excessive living organisms which may clog or coat operative parts of marine vessels/equipment.
5.	Fecal Coliform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.
6.	Biochemical Oxygen Demand (3 days at 27°C)	5 mg/l	To maintain water relatively free from pollution caused by sewage and other decomposable wastes.

Table 8.8: Primary Water Quality Criteria for Class SW-V Waters (for navigation and controlled waste disposal)

S.No	Parameter	Standards	Rationale / Remarks
1.	pH range	6.0-9.0	As specified by New England Interstate Water Pollution Control Commission
2.	Dissolved Oxygen	3.0 mg/1 or 40 percent saturation value whichever is higher	To protect aquatic lives
3.	Colour and Odour	None in such concentrations that would impair any usages specifically assigned to this class	As in (1) above
4.	Sludge deposits, Solid refuse floating solids, oil, grease & scum	None except for such small amount that may result from discharge of appropriately treated sewage and / or industrial, waste effluents.	As in (1) above
5.	Fecal Collform	500/100 ml (MPN)	Not exceeding 1000/100 ml in 20 percent of samples in the year and in 3 consecutive samples in monsoon months.

8.2.3 Disposal of wastewater / discharge of environmental pollutants

Schedule VI of the Environment (Protection) Rules gives the “General Standards for discharge of environmental pollutants”. This includes discharge into inland surface

water, public sewers, land for irrigation and marine coastal areas. The standards for the various parameters are listed in Table 8.9 [6]

Table 8.9: Standards for Disposal Part - A : Effluents

S. No.	*Parameter*	*Inland surface water*	*Public sewers*	*Land for irrigation*	*Marine/coastal areas*
1	2	3			
		(a)	(b)	(c)	(d)
1	Colour and odour	See 6 of Annexure-I		See 6 of Annexure-I	See 6 of Annexure-I
2	Suspended solids mg/l, max.	100	600	200	(a) For process waste water (b) For cooling water effluent 10 per cent above total suspended matter of influent.
3	Particle size of suspended solids	shall pass 850 micron IS Sieve	-	-	(a) Floatable solids, solids max. 3 mm (b) Settleable solids, max 856 microns
4	pH value	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0	5.5 to 9.0
5	Temperature	shall not exceed 5°C above the receiving water temperature			shall not exceed 5°C above the receiving water temperature
6	Oil and grease, mg/l max,	10	20	10	20
7	Total residual chlorine, mg/l max	1.0	-	-	1.0
8	Ammonical nitrogen (as N),mg/l, max.	50	50	-	50
9	Total Kjeldahl nitrogen (as N);mg/l, max. mg/l, max.	100	-	-	100
10	Free ammonia (as NH_3),	5.0	-	-	5.0

S. No.	Parameter	Inland surface water	Public sewers	Land for irrigation	Marine/coastal areas
	mg/l,max.				
11	Biochemical oxygen demand (3 days at 27°C), mg/l, max.	30	350	100	100
12	Chemical oxygen demand, mg/l, max.	250	-	-	250
13	Arsenic(as As).	0.2	0.2	0.2	0.2
14	Mercury (As Hg), mg/l, max.	0.01	0.01	-	0.01
15	Lead (as Pb) mg/l, max	0.1	1.0	-	2.0
16	Cadmium (as Cd) mg/l, max	2.0	1.0	-	2.0
17	Hexavalent chro-mium (as Cr + 6),mg/l, max.	0.1	2.0	-	1.0
18	Total chromium (as Cr) mg/l, max.	2.0	2.0	-	2.0
19	Copper (as Cu)mg/l, max.	3.0	3.0	-	3.0
20	Zinc (as Zn) mg/l, max.	5.0	15	-	15
21	Selenium (as Se)	0.05	0.05	-	0.05
22	Nickel (as Ni) mg/l, max.	3.0	3.0	-	5.0
23	Cyanide (as CN) mg/l, max.	0.2	2.0	0.2	0.2
24	Fluoride (as F) mg/l, max.	2.0	15	-	15
25	Dissolved phos- phates (as P), mg/l, max.	5.0	-	-	-
26	Sulphide (as S) mg/l, max.	2.0	-	-	5.0

S. No.	Parameter	Inland surface water	Public sewers	Land for irrigation	Marine/coastal areas
27	Phenolic compounds (as C6H50H) mg/l, max.	1.0	5.0	-	5.0
28	Radioactive materials: (a) Alpha emitters micro curie mg/l, max. (b)Beta emitters microcurie mg/l	10 -7 10 -6	10 -7 10 -6	10 -8 10 -7	10 -7 10 -6
29	Bio-assay test	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent	90% survival of fish after 96 hours in 100% effluent
30	Manganese	2 mg/l	2 mg/l	-	2 mg/l
31	Iron (as Fe)	3mg/l	3mg/l	-	3mg/l
32	Vanadium (as V)	0.2mg/l	0.2mg/l	-	0.2mg/l
33	Nitrate Nitrogen	10 mg/l	-	-	20 mg/l

* These standards shall be applicable for industries, operations or processes other than those industries, operations or process for which standards have been specified in Schedule of the Environment Protection Rules, 1989.

Annexure-I: (For the purpose of Parts-A, B and C): Under Annexure-I, a list of guidelines has been provided to enable state boards in enforcing standards specified under Schedule IV. The guidelines of relevance to water pollution /wastewater / effluent disposal alone are listed here.

1. The wastewater and gases are to be treated with the best available technology (BAT) in order to achieve the prescribed standards.
2. The industries need to be encouraged for recycling and reuse of waste materials as far as practicable in order to minimise the discharge of wastes into the environment.

4. While permitting the discharge of effluents and emissions into the environment, State Boards have to take into account the assimilative capacities of the receiving bodies, especially water bodies so that quality of the intended use of the receiving waters is not affected. Where such quality is likely to be affected, discharges should not be allowed into water bodies.

5. The standards mentioned in this Schedule shall also apply to all other effluents discharged such as mining, and mineral processing activities and sewage.

6. All effluents discharged including from the industries such as cotton textile, composite woollen mills, synthetic rubber, small pulp & paper, natural rubber, petrochemicals, tanneries, paint, dyes, slaughter houses, food & fruit processing and dairy industries into surface waters shall conform to the BOD limit specified above, namely, 30 mg/l. For discharge of an effluent having a BOD more than 30 mg/l, the standards shall conform to those given above for other receiving bodies, namely, sewers, coastal waters and land for irrigation.

7. In case of pesticides.

a. The limits should be complied with at the end of the treatment plant before dilution.

b. Bio-assay test should be carried out with the available species of fish in the receiving water, the COD limits to be specified in the consent conditions should be correlated with the BOD limits.

c. In case metabolites and isomers of the pesticides in the given list are found in significant concentrations, standards should be prescribed for these also in the same concentration as the individual pesticides.

d. Industries are required to analyse pesticides in wastewater by advanced analytical methods such as GLC/HPLC.

8. The chemical oxygen demand (COD) concentration in a treated effluent, if observed to be persistently greater than 250 mg/l before disposal to any receiving body (public sewer, land for irrigation, inland surface water and marine coastal areas), such industrial units are required to identify chemicals causing the same. In case these are found to be toxic as defined in the Schedule-I of the Hazardous Rules, 1989, the state boards in such cases shall direct the industries to install tertiary treatment stipulating time limit.

9. Standards specified in Part A of Schedule-VI for discharge of effluents into the public sewer shall be applicable only if such sewer leads to a secondary treatment including biological treatment system otherwise the discharge into sewers shall be treated as discharge into inland surface waters.

8.2.4 Standards for disposal for some coastal industries/activities

In addition to such standards, industries/activities located on the coast have their own sets of standards for effluent quality for disposal. Such activities include oil drilling and gas extraction industry, thermal power plants and coastal aquaculture. Salient points from the standards prescribed for the above three activities are given below:

Oil Drilling & Gas Extraction Industry [7]

Table 8.10: Standards for Liquid Effluent

	Parameters	**Concentration not to exceed**
1.0 On-shore facilities (for marine disposal)	pH Oil & grease Suspended solids BOD, 27°C for 3 days	5.5-9.0 10 mg/l 100 mg/l 30 mg/l

Note:
For on-shore discharge of effluents, in addition to the standards prescribed above, proper marine outfall has to be provided to achieve the individual pollutant concentration level in sea water below their toxicity limits as given in Table 8.11, within a distance of 50 metres from the discharge point, in order to protect the marine aquatic life :

Table 8.11: Individual Pollutant Concentration in Sea Water

Parameter	**Toxicity limit mg/l**
Chromium, as Cr	0.1
Copper, as Cu	0.05
Cyanide, as CN	0.005
Fluoride, as F	1.5
Lead, as Pb	0.05
Mercury, as Hg	0.01
Nickel, as Ni	0.1
Zinc, as Zn	0.1

1. Off-shore facilities
   For off-shore discharge of effluents, the oil content of the treated effluent without dilution shall not exceed 40 mg/l for 95% of the observation and shall never exceed 100 mg/l. Three 8 hourly grab samples are required to be collected daily and the average value of soil and grease content of the three samples should comply with these standards.

Temperature Limit for Discharge of Condenser Cooling Water from Thermal Power Plant [8]

B. New projects in coastal areas using sea water.

The thermal power plants using sea water should adopt suitable system to reduce water temperature at the final discharge point so that the resultant rise in the temperature of receiving water does not exceed 7°C over and above the ambient temperature of the receiving water bodies.

D. Guidelines for discharge point:

2. In case of discharge of cooling water into sea, proper marine outfall shall be designed to achieve the prescribed standards. The point of discharge may be selected in consultation with concerned State Authorities/NIO.

3. No cooling water discharge shall be permitted in estuaries or near ecologically sensitive areas such as mangroves, coral reefs/spawning and breeding grounds of aquatic flora and fauna.

Standards for coastal aquaculture [9]

Table 8.12: Standards for Treatment of Wastewater Discharged from the Aquaculture farms, Hatcheries, Feed mills and Processing Units

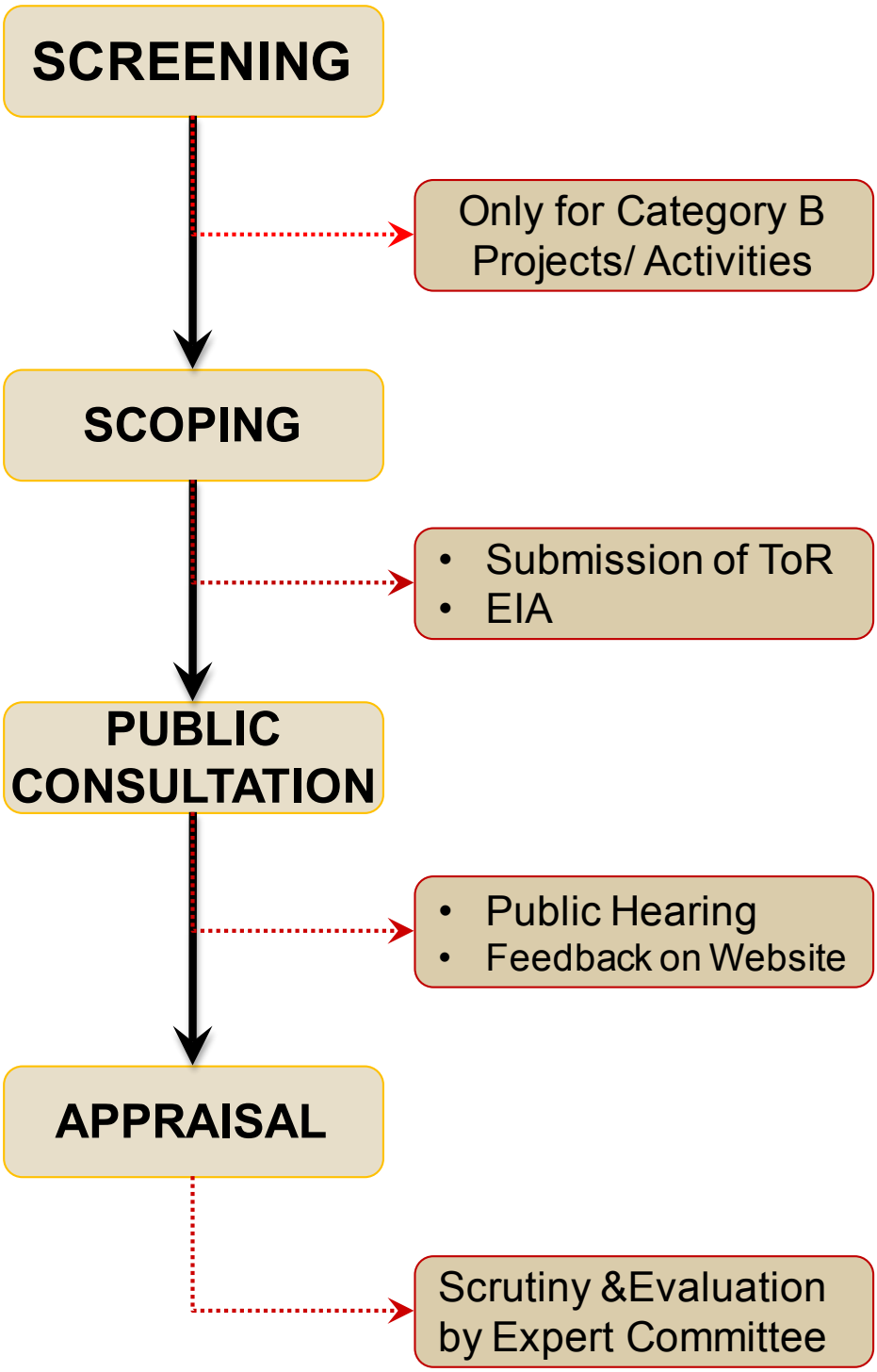
S. No.	*Antibiotics and other Pharmacologically*	*Final Discharge Point*	
	Active Substances	*Coastal Marine Waters*	*Creek or estuarine courses when the same inland water courses are used as water source & disposal point*
1	pH	6.0 – 8.5	6.0 – 8.5
2	Suspended solids mg/l	100	100
3	Dissolved oxygen mg/l	Not less than 3	Not less than 3
4	Free Ammonia (as NH_3-N) mg/l	1	0.5
5	Biochemical Oxygen Demand-BOD (5 days @ 20 c) Max mg/l	50	20
6	Chemical Oxygen Demand-COD mg/l	100	75
7	Dissolved Phosphate (as P) mg/l	0.4	0.2
8	Total Nitrogen (as N) mg/l	2	2

8.3 EIA/SIA For Clearance and Approval of Projects that have Potential Impacts on Water Quality and Coastal and Marine Environment in General

The EIA Notification, 2006: One of the initiatives for environmental protection and sustainable development is the Notification on Environmental Impact Assessment (EIA) of developmental projects issued on 27.1.1994 under the provisions of Environment (Protection) Act, 1986 making EIA mandatory for 29 categories of developmental projects. One more item was added to the list in January, 2000. The notification was amended in 2006. This notification states that new projects or activities or the expansion or modernization of existing projects or activities listed in the Schedule to this notification entailing capacity addition with change in process and or technology shall be undertaken in any part of India only after the prior environmental clearance from the Central Government or as the case may be, by the State Level Environment Impact Assessment Authority (SEIAA).

All projects and activities are broadly categorized in to two categories - Category A and Category B, based on the spatial extent of potential impacts and potential impacts on human health and natural and man-made resources. Projects in Category A require clearance from the Central Government in the Ministry of Environment while Category B projects would require consent from duly constituted SEIAA. In the absence of an SEIAA, the project would be treated as a Category A project. Clearance is done by a process with a maximum of four stages as given below in Fig. 8.1

Fig. 8.1: Flow of Clearance pathways for Projects attracting EIA



Stage (1) Screening (Only for Category 'B' activities) – The State Environmental Appraisal Committee (SEAC) will determine whether it requires further environmental studies for preparation of an EIA. The projects requiring an EIA report shall be termed as Category 'B1' and remaining projects shall be termed as Category 'B2'.

Stage (2) Scoping – DAC or SEAC will determine detailed and comprehensive Terms of Reference (TOR) addressing all relevant environmental concerns for the preparation of an EIA. Construction / Township / Commercial Complexes/ Housing shall not require Scoping. Applications for prior EC may be rejected at this stage itself.

Stage (3) Public Consultation – All Category 'A' and Category 'B1' activities shall undertake Public Consultation (except 6 items). It shall have two components comprising of (a) a public hearing at site, or in close proximity, and (b) obtain responses in writing from other concerned persons. The public hearing shall be conducted by the State Pollution Control Board (SPCB) within 45 days of a request to the effect from the applicant. The concerned regulatory authority and the SPCB shall invite responses by placing on their website the Summary EIA report prepared in the format along with a copy of the application within seven days of the receipt of a written request for arranging the public hearing. After completion of the public consultation, the applicant shall address all the material environmental concerns expressed during this process, and make appropriate changes in the draft EIA and EMP.

Stage (4) Appraisal – Appraisal means the detailed scrutiny by the EAC or SEAC in a transparent manner in a proceeding to which the applicant shall be invited for furnishing necessary clarifications in person or through an authorized representative.

For all applications seeking prior EC for expansion, the EAC or SEAC will decide on the due diligence necessary including preparation of EIA and public consultations. The regulatory authority shall consider the recommendations of the EAC or SEAC concerned and convey its decision to the applicant.
The list of projects requiring environmental clearance includes, among others:

- Mining, extraction of natural resources and power generation (for a specified production capacity) e.g. Offshore and onshore oil and gas exploration, development & production; thermal power plants
- Physical Infrastructure including Environmental Services: ports and harbours, ship breaking yards, Common Effluent Treatment Plant (CETP)

A detailed EIA report has to be prepared by accredited consultants after presenting a ToR to an expert committee. A guidance manual has been prepared for preparation of EIA reports to ensure that they are complete and inclusive. Chapter 2 of the EIA Manual [10] is on the identification of key issues. Section 2.7 is on Wastes and Emissions. Box C on "liquid effluents" (Table 8.13) lists the various possible sources that need to be included in the assessment process.

Table 8.13: Process and Domestic Effluents

o Offsite effluents o Storm water o Cooling tower effluents and boiler blow downs o Effluents from treatment plant o Effluents from emission mitigation system o Acid Drainage o Tailing Residue emplacement o Ground / surface water contamination o Accidental / emergency & spills

Section 2.7.2 shows that detailed assessment will be required where:

- the proposed receiving body is surface water, irrigation canal, marine coast, public sewers etc.
- the discharge point is within the catchment area of a drinking water source or a river stretch designated for drinking purposes (as per CPCB designated usages)
- the disposal is on land, the soil is permeable and the aquifer conditions are prone to groundwater contamination

Clearance at State Level

With respect to all projects, consent has to be first obtained from the State Pollution Control Board of the state in which the project is located. The State Pollution Board enforces the Water (Prevention and Control of Pollution) Act, 1974 in which Sections 25 states that the consent of the (State) Board is needed for the establishment of any industry and for operation or process, the discharge of sewage/trade effluent into any stream or well or sewer or on land. A standardized format is available with the Pollution Control Board which includes a section where information on the quantum of sewage and/ or trade effluent to be generated along with mode of disposal and whether treatment systems are being constructed have to be provided in fair detail. In the case of trade effluent generating units, Effluent Treatment proposal must be enclosed which must contain the following details:

- breakup quantity of water requirement with sources,
- breakup quantity of trade effluent,
- sources of trade effluent,
- characteristics of wastewater,
- treatment methodology,
- mode of disposal,
- design criteria for various units,
- detailed drawing of Effluent Treatment Plant and its layout,
- diagram showing the hydraulic profile and mode of disposal of treated effluent and its adequacy [11].

Industries are classified based on their water-polluting capacities into Red, Orange and Green. Table 8.14 gives the list according to the Ministry of Environment and Forests. The **consent fee** payable to the state pollution control board is fixed on the basis of the classification of the industry as well as the gross fixed assets of the industry.

Table 8.14: Classification of Industries for Consent Management

SCHEDULE - VIII [see rules 3(2) and 12] **Classification of industries for consent management** **[Red, Orange & Green Categories]**		
I. LIST OF INDUSTRIES UNDER 'RED' CATEGORY A. Industries identified by Ministry of Environment & Forests, Govt. of India as heavily polluting and covered under Central Action Plan, viz. (1) Distillery including Fermentation industry. (2) Sugar (excluding Khandsari) (3) Fertiliser. (4) Pulp & Paper (Paper manufacturing with or without pulping). (5) Chlor alkali (6) Pharmaceuticals (Basic) (excluding formulation). (7) Dyes and Dye-intermediates. (8) Pesticides (Technical) (excluding formulation). (9) Oil refinery (Mineral oil or Petro refineries). (10) Tanneries (11) Petrochemicals (Manufacture of and not merely use of as raw material). (12) Cement (13) Thermal power plants (14) Iron and Steel (Involving processing from ore/ scrap/Integrated steel plants) (15) Zinc smelter (16) Copper smelter (17) Aluminium smelter	**II. LIST OF INDUSTRIES 'ORANGE" CATEGORY.** (1) Manufacture of mirror from sheet glass and photoframing. (2) Cotton spinning and weaving. (3) Automobile servicing and repairs stations. (4) Hotels and restaurants. (5) Flour mills (excluding Domestic Aatta Chakki) (6) Malted food. (7) Food including fruits and vegetable processing. (8) Pulping and fermenting of coffee beans. (9) Instant tea/coffee, coffee processing. (10) Non-alcoholic beverages (soft drinks) (11) Fragrances and industrial perfumes. (12) Food additives, nutrients and flavours. (13) Fish processing. (14) Organic nutrients. (15) Surgical and medical products not involving effluent/ emission generating processes.	**III. LIST OF INDUSTRIES UNDER "GREEN" CATEGORY'.** A. Industries in Small Scale, Cottage/Village category suggested under notification of the State Government/Union Territory for issuance of simplified NOC/Consent from State Pollution Control Board/Pollution Control Committee, as the case may be. B. All those industries or processes which are not covered under the "Red" and/or "Orange" category; An illustrative list is provided below. (1) Wasting of used sand by hydraulic discharge. (2) Atta-chakkies. (3) Rice millers. (4) Steeping and processing of grains. (5) Mineralised water. (6) Dal mills. (7) Bakery products, biscuits confectionery. (8) Groundnut decorticating (dry).

SCHEDULE - VIII
[see rules 3(2) and 12]
Classification of industries for consent management
[Red, Orange & Green Categories]

B. Industries manufacturing following products or carrying out following activities (1) Tyres and tubes Vulcanisation/Retreading/ moulding). (2) Synthetic rubber. (3) Glass and fibre glass production and processing. (4) Industrial carbon including electrodes and graphite blocks, activated carbon, carbon black etc. (5) Paints and varnishes (excluding blending/mixing). (6) Pigments and intermediates. (7) Synthetic resins. (8) Petroleum products involving storage, transfer or processing. (9) Lubricating oils, greases or petroleum - based products. (10) Synthetic fibre including rayon, tyre cord, polyester filament yarn. (11) Surgical and medical products involving prophylactics and latex. (12) Synthetic detergent and soap. (13) Photographic films and chemicals. (14) Chemical, petrochemical and electrochemicals including manufacture of acids such as Sulphuric Acid, Nitric Acid, Phosphoric Acid etc. (15) Industrial or inorganic gases. (16) Chlorates, perchlorates and peroxides. (17) Glue and gelatine. (18) Yarn and textile processing involving scouring, bleaching, dyeing, printing or any effluent/emission generating process. (19) Vegetable oils including solvent extracted oils, hydro-	(16) Laboratory-wares. (17) Wire drawing (cold process) and bailing straps. (18) Stone crushers. (19) Laboratory chemicals involving distillation, purification process. (20) Tyres and tubes vulcanisation, vulcanisation, retreading, moulding. (21) Pesticides/Insecticides/ Fungicides/ Herbicides/ Agro chemical formulation. (22) NPK Fertilisers/ Granulation. (23) Pharmaceuticals formulation. (24) Khandsari sugar. (25) Pulverizing units.	(9) Supari (Betelnut) and masala grinding. (10) Chilling plants and cold storages. (11) Ice-cream or Ice-making. (12) Tailoring and garment making. (13) Cotton and woolen hosiery. (14) Apparel making (15) Handloom weaving (16) Shoelace manufacturing (17) Gold and silver thread zari work. (18) Gold and silver smithy. (19) Leather footwear and leather products excluding tanning and hide processing. (20) Musical instruments manufacturing. (21) Sports goods. (22) Bamboo and cane products (only dry operations) (23) Cardboard or corrugated box and paper products (Paper or pulp manufacturing excluded). (24) Insulation and other coated papers (Paper or pulp manufacturing excluded). (25) Scientific and mathematical instruments. (26) Furniture (wooden and steel). (27) Assembly of domestic electrical appliances.

SCHEDULE - VIII
[see rules 3(2) and 12]
Classification of industries for consent management
[Red, Orange & Green Categories]

generated oils. (20) Industry or process involving metal treatment or process such as picking, surface coating, paint baking, paint stripping, heat treatment, phosphating or finishing etc. (21) Industry or process involving electroplating operations. (22) Asbestos and asbestos-based industries. (23) Slaughter houses and meat processing units. (24) Fermentation industry including manufacture of yeast, beer etc. (25) Steel and steel products including coke plants involving use of any of the equipment's such as blast furnaces, open hearth furnance, induction furnance (26) Incineration plants (27) Power generating plants (excluding D.G. Sets). (28) Lime manufacturing (29) Tobacco products including cigarettes and tobacco processing. (30) Dry coat processing/ Mineral processing industries like ore sintering, palletization, etc. (31) Phosphate rock processing plants. (32) Coke making, coal liquefaction, coaltar distillation or fuel gas making. (33) Phosphorous and its compounds. (34) Explosives including detonators, fuses etc. (35) Fire crackers. (36) Processes involving chlorinated hydrocarbons. (37) Chlorine, fluorine, bromine, iodine and their compounds.		(28) Radio assembling. (29) Fountain pens. (30) Polythene, plastic and P.V.C. goods through extrusion moulding. (31) Rope (cotton and plastic). (32) Carpet weaving. (33) Assembly of air coolers, conditioners. (34) Assembly of bicycles, baby carriage and other small non-motorised vehicles. (35) Electronics equipment (Assembly). (36) Toys. (37) Water softening and demineralised plants. (38) Paint (by mixing process only). (39) Candles. (40) Carpentry (excluding saw mill). (41) Oil ginning/expelling (no hydrogenation/refining). (42) Jobbing and machining. (43) Manufacture of steel trunks and suitcases. (44) Paper pins and U-clips. (45) Block making for printing. (46) Optical frames. (47) Powerlooms/ handlooms (without dyeing & bleaching). (48) Printing press. (49) Garments stitching, tailoring. (50) Thermometer

SCHEDULE - VIII [see rules 3(2) and 12] **Classification of industries for consent management** **[Red, Orange & Green Categories]**		
(38) Hydrocyanic acid and its derivatives. (39) Milk processing and dairy products (Integrated Project). (40) Industry or process involving foundry operations. (41) Potable alcohol (IMFL) by blending or distillation of alcohol. (42) Anodizing. (43) Ceramic/ refractories. (44) Lead processing and battery reconditioning & manufacturing including lead smelting. (45) Hot Mix plants (46) Hospitals (47) Mining and ore-beneficiation		making. (51) Footwear (rubber). (52) Plastic processed goods. (53) Medical and surgical instruments (54) Electronic and electrical goods. (55) Rubber goods industry.
Note: The industry which do not fall in any of the above mentioned three categories (i.e. Red/Orange/Green), decision with regard to their categorisation will be taken by a committee at Head. Office level comprising of the Member Secretary and two senior offices of the Board/Committee. *Source:* http://envfor.nic.in/legis/ucp/ucpsch8.html		

8.4 Other Instruments and Key Sectoral Policies

8.4.1 Policy Statement for Abatement of Pollution

Pollution control in India has mainly focused on end-of-pipe solutions by means of various treatment processes. The Policy Statement for Abatement of Pollution [12] dated 26th February 1992 says that “The policy elements seek to shift emphasis from defining objectives for each problem area towards actual implementation, but the focus is on the long term because pollution particularly affects the poor”. And, “To achieve the objectives maximum use will be made of a mix of instruments in the form of legislation and regulation, fiscal incentives, voluntary agreements, educational programmes and information campaigns. The emphasis will be on increased use of regulations and an increase in the development and application of financial incentives. Section 3.3 says:

> The objective is to integrate environmental considerations into decision making at all levels. To achieve this, steps have to be taken to:
> - prevent pollution at source;

- encourage, develop and apply the best available practicable technical solutions;
- ensure that the polluter pays for the pollution and control arrangements; focus protection on heavily polluted areas and river stretches; and
- involve the public in decision making.

8.4.2 National Conservation Strategy and Policy Statement on Environment and Development, 1992 [13]

This statement talks extensively about the problems of pollution as well as various approaches taken towards reduction of pollution.

Section 6.1 on Agriculture calls for

> "Phasing out and stoppage of persistent and toxic pesticides and their substitution by environmentally safe and appropriate pesticides".

Section 6.5 on Industrial Development calls for

- Operationalisation of 'polluter pays principle' by introducing effluent tax, resource cess for industry and implementation of standards based on resource consumption and production capacity;
- Fiscal incentives to small- scale industries for pollution control and for reduction of wastes;
- Collective efforts for installation and operation of common effluent treatment facilities in industrial estates and in areas with a cluster of industries
- Introduction of 'Environmental Audit' and reports thereof to focus on environment related policies, operations and activities in industrial concerns with specific reference to pollution control and waste management;

8.4.3 National Environmental Policy, 2006 [14]

With respect to water pollution abatement, the Environment Policy outlines an action plan as follows:

> a) Develop and implement, initially on a pilot scale, public-private partnership models for setting up and operating effluent and sewage treatment plants. Once the models are validated, progressively use public resources, including external assistance, to catalyze such partnerships. Enhance the capacities of municipalities for recovery of user charges for water and sewage systems.
>
> b) Prepare and implement action plans for major cities for addressing water pollution, comprising regulatory systems relying on appropriate combination of fiats and incentive based instruments, projects implemented through public agencies as well as public-private partnerships for treatment, reuse, and

recycle where applicable, of sewage and wastewater from municipal and industrial sources, before final discharge to water bodies.

c) Take measures to prevent pollution of water bodies from other sources, especially waste disposal on lands.

d) Enhance capacities for spatial planning among the State and Local Governments, with adequate participation by local communities, to ensure clustering of polluting industries to facilitate setting up of common effluent treatment plants, to be operated on cost recovery basis. Ensure that legal entity status is available for common effluent treatment plants to facilitate investments, and enable enforcement of standards.

e) Promote R&D in development of low cost technologies for sewage treatment at different scales, in particular, replication of the East Kolkata wetlands and other bio-processing based models for sewage treatment, to yield multiple benefits.

f) Take explicit account of groundwater pollution in pricing policies of agricultural inputs, especially pesticides, and dissemination of agronomy practices. Encourage Integrated Pest Management (IPM) and use of biodegradable pesticides.

With respect to Environmental Standards, the policy says that the following specific actions will be taken:

a) Set up a permanent machinery comprising experts in all relevant disciplines to review notified ambient and emissions standards in the light of new scientific and technological information as they become available, and changing national circumstances, ensuring adequate participation by potentially impacted communities, and industry associations.

b) Strengthen the testing infrastructure and network for monitoring ambient environmental quality, including through participation by local communities, and public-private partnerships. Progressively ensure real-time, and on-line availability of the monitoring data.

8.4.4 Cruise Shipping Policy [15]

India had developed a policy for Cruise Shipping with the recent emergence as a new marketable commodity/product.

Section 7.7 on Waste Disposal reads as follows:

> 7.7.1 The Cruise liners will be mandatorily asked to comply with all requirements of Marine Pollution (MARPOL) Convention and its annexes and to follow the guidelines of Indian Maritime Administration to ensure inter-alia the following:
>
> - No waste (sewage waste, solid waste, waste/contaminated water or used oil) will be released or dumped into the sea or on islands during the cruise ship tour in Indian waters.
> - Any boat or smaller vessel taking tourists to an island destination in India will ensure that no litter or waste is thrown over-board or left littering the island. All waste originating from the mother ship will be disposed off in a manner stipulated by the Maritime Administration.
> - No oily or contaminated bilge water will be released in Indian territorial waters except in emergency situations where the vessel is taking on water to the extent that the safety of the vessel or those aboard will be threatened.

8.5 Market Based Instruments

Inadequate pricing of the environment results in environmental pollution problems. Common property resources, especially water sources, are considered free for dumping wastes. This affects other users of the resource. Hence there are two major types of instruments that are used to correct this distortion namely:

- Command and Control (CAC) Measures: mandatory norms and standards imposed by regulatory authorities
- Economic/Market Based instruments (MBI): taxes/ charges / subsidies

Traditionally, the regime in India has been of the CAC type. As discussed in the earlier section, water quality standards have been established and published in the form of the Environment (Protection) Rules. The Central Pollution Control Board and the State Pollution Control Board have vested in them the power to enforce these rules and impose penalties in the form of fines or imprisonment or even serve notices to close down an industry or activity that is causing pollution. However, it is also an accepted fact that such a CAC regime has not really worked as the problem of pollution appears to have only intensified over the years.

Consequently, in the policy statement on the abatement of pollution, there has been a shift with more emphasis on prevention of pollution and hence there is greater move towards MBI. Towards this a number of fiscal incentives have been made as follows [16]:

- The Water (Prevention and Control of Pollution) Cess Act provides for a 25% rebate on the cess payable if the person or local authority concerned installs a plant for treatment of sewage or trade effluent

- The World Bank assisted Industrial Pollution Prevention Project is targeted at introducing Cleaner Technologies in industrial units. Under the investment component of the Project, the World Bank line of credit is available to industrial units for undertaking appropriate measures for Pollution abatement, with a focus on Waste Minimisation and adoption of Cleaner Production methodologies.

- The customs duty on some specified pollution control equipment has been reduced to a concessional rate of 35%. The countervailing duty has also been eliminated for such items and auxiliary duty has been reduced to 5%. Since March 1992, a rebate of over 5% has been allowed on excise duty of over 5%. In addition to the rebate on customs and excise duties levied by the Central Government, certain states too have offered concessions on Sales Tax for specified pollution control equipment

- There is provision for allowing the deduction of a certain percentage of written down actual cost of capital assets, net of any subsidies and concessions from gross profit in computing the base for levy of corporate tax. A notification issued in February, 1983 introduced for the first time a higher rate of depreciation for pollution control equipment as compared to 25% applicable for the general plant and machinery. This 30% was gradually increased to 100% in 1993-94 budget.

- A provision is available in the Income Tax Act under which a company can deduct up to 25% of the actual cost of some specified new assets for computation of taxable profit. This allowance was raised to 35% for pollution control equipment.

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1 NGRBA http://moef.nic.in/modules/recent-initiatives/NGRBA/index.html

2 MoEF signs MoU with IIT consortium to prepare Ganga River Basin Management Plan. New Delhi: July 6, 2010. http://moef.nic.in/downloads/public-information/DOC20100706.pdf

3 CPCB, Water Quality Standards for Coastal Waters Marine Outfalls. http://www.cpcb.nic.in/oldwebsite/Environmental%20Standards/Effluent/standard64.html

4 CPCB, 2008. Guidelines for Water Quality Management. http://www.cpcb.nic.in/upload/NewItems/NewItem_97_guidelinesofwaterqualitymanagement.pdf

5 MoEF, 1998. Environment (Protection) (Second Amendment) Rules, 1998 Notification dated the 22nd December, 1998 http://www.envfor.nic.in/legis/noise/gsr7.htm

6 CPCB. General Standards for Discharge Of Environmental Pollutants http://www.cpcb.nic.in/oldwebsite/Environmental%20Standards/Emission/standard32.html

7 CBCB. Oil Drilling & Gas Extraction Industry. Standards for Liquid Effluent. http://www.cpcb.nic.in/oldwebsite/Environmental%20Standards/Effluent/standard46.html Source : EPA Notification [GSR 176(E), April, 1996]

8 CPCB. Temperature Limit for Discharge of Condenser Cooling Water from Thermal Power Plant http://www.cpcb.nic.in/oldwebsite/Environmental%20Standards/Effluent/standard63_2.html; Source: EPA Notification [GSR 7, dated Dec. 22, 1998]

9 Coastal Aquaculture Authority. Standards for treatment of wastewater discharged from the aquaculture farms, hatcheries, feed mills and processing units http://www.caa.gov.in/standards_caa/waste_water.htm

10 EIA: A Manual. IA Division, MoEF, GoI, 2001. http://envfor.nic.in/divisions/iass/eia/Cover.htm It is mandatory for all developmental projects to undergo an environmental appraisal. Guidelines for these are available on the MoEF website (www.envfor.nic.in). Projects that are located in coastal areas require additional clearance on CRZ status.

11 The Tamil Nadu Pollution Control Board has a form for Industries (available at http://www.tnpcb.gov.in/pdf/Water_appln.pdf) which is the "Application for consent under Section 25/26 of the Water (Prevention and Control of Pollution) Act, 1974 as amended (Central Act, 6 of 1974) (See Rule 26 of the Tamilnadu Water (Prevention and Control of Pollution) Rules, 1983). This section is based on details to be provided in the form for Tamil Nadu.

12 Government of India, MoEF, 1992. Policy Statement for Abatement of Pollution, http://moef.nic.in/downloads/about-the-ministry/introduction-psap.pdf

13 GoI, MoEF, 1992. National Conservation Strategy and Policy Statement on Environment and Development, 1992 http://moef.gov.in/divisions/csurv/csps.htm

14 Government of India, MoEF, 2006. National Environmental Policy. http://www.envfor.nic.in/nep/nep2006e.pdf

15 Ministry of Shipping, Cruise Shipping Policy: http://shipping.gov.in/writereaddata/linkimages/Cruise%20Shipping%20Policy6621422610.pdf

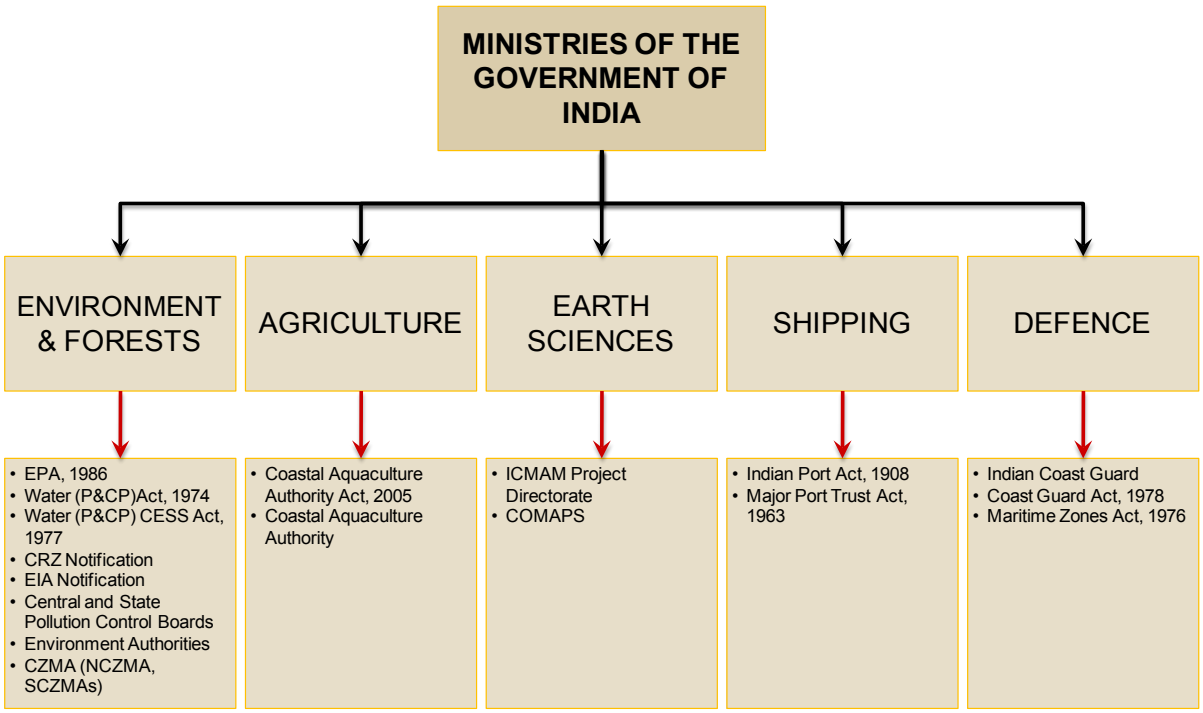
16 Source: http://wmc.nic.in/chapter1-Initiatives-prevention.ASP#5.0

CHAPTER 9: INSTITUTIONAL MECHANISMS FOR POLLUTION CONTROL AND ENFORCEMENT OF EXISTING POLICIES AND LEGISLATIONS

9.1. Complex Institutional Arrangements

Institutional mechanisms for pollution control exist at multiple levels. At the Central Government level are the Central Ministries. Institutions set up under various Acts function under the ministries. Many of the institutions are tiered in structure – with a Central unit and State units with defined activities. In this section, the important ministries at the central level that play a role in the pollution / control of coastal waters are discussed. The figure gives an overview of the ministries and institutions as well as the Acts/ activities they administer.

Fig. 9.1: Overview of the ministries and institutions- the acts/ activities they administer



9.2. Ministry of Environment and Forests

The broad objectives of The Ministry of Environment and Forests, Government of India, include the prevention and control of pollution, conservation of resources and the protection of the environment. These objectives are well supported by a set of legislative and regulatory measures, aiming at the preservation, conservation and protection of the environment. The most important of the legislative measures is the Environment (Protection) Act which is administered by the Ministry. There are also a

number of laws to aid in prevention and control of pollution which have set up some of the institutional mechanisms required for pollution control and enforcement of the laws. The Water (Prevention and Control of Pollution) Act, 1974 enabled the setting up of the Central and State Pollution Control Boards. The EPA, 1986, says that the Central Government (or an officer empowered by it) can take, for the purpose of analysis, samples of air, water or any substance following due procedure and that the results of such analysis would be admissible as legal evidence.

A number of notifications have been set out under the EPA of which the EIA and CRZ are the most relevant in the context of this report. Environmental Clearance of Projects at the Central level is carried out by the Expert Appraisal Committees for various categories of projects and by the Infrastructure committee for infrastructure related and CRZ related projects. Monitoring of projects with respect to conditions stipulated in the environmental clearance issued under EIA Notification 2006 and Coastal Regulation Zone 1991 is carried out through the six Regional Offices of the MoEF. The monitoring report is scrutinized in the Ministry and on that basis appropriate action is contemplated under the Environment (Protection) Act, 1986 for violation of environmental clearance conditions. A procedure has been laid down for issuing show-cause notice, closure of industry etc. in September 2009.

Section 15 of the EPA, 1986 gives the penalty for contravention of the provisions of the Act and the rules, orders and directions as “punishable with imprisonment for a term which may extend to five years or with fine which may extend to one lakh rupees, or with both, and in case the failure or contravention continues, with additional fine which may extend to five thousand rupees for every day during which such failure or contravention continues after the conviction for the first such failure or contravention”. And if the failure or contravention continues beyond a year, the penalty would be imprisonment for upto seven years.

9.2.1. The Central Pollution Control Board [1]

The Central Pollution Control Board (CPCB) was constituted as Central Board for the Prevention and Control of Water Pollution (CBPCWP) on 22nd September, 1974 under the provisions of The Water (Prevention & Control of Pollution) Act, 1974. Under the Water (Prevention & Control of Pollution) Amendment Act 1988 (No. 53 of 1988), its name was amended as Central Pollution Control Board.
The main function of CPCB with regard to water pollution, as spelt out in The Water (Prevention and Control of Pollution) Act, 1974, is:

- To promote cleanliness of streams and wells in different areas of the States through prevention, control and abatement of water pollution [2]

The CPCB also functions as the State Board for the Union Territories (Centrally Administered Territories in India) by laying down standards for treatment and disposal of sewage and effluents.

The Central Pollution Control Board is fully funded by the Central Ministry of Environment & Forests.

The functions of the Central Board at the National Level are [3]:

- Advise the Central Government on any matter concerning prevention and control of water and air pollution and improvement of the quality of air.
- Plan and cause to be executed a nation-wide programme for the prevention, control or abatement of water and air pollution;
- Co-ordinate the activities of the State Board and resolve disputes among them;
- Provide technical assistance and guidance to the State Boards, carry out and sponsor investigation and research relating to problems of water and air pollution, and for their prevention, control or abatement;
- Plan and organize training of persons engaged in programme on the prevention, control or abatement of water and air pollution;
- Organize through mass media, a comprehensive mass awareness programme on the prevention, control or abatement of water and air pollution;
- Collect, compile and publish technical and statistical data relating to water and air pollution and the measures devised for their effective prevention, control or abatement;
- Prepare manuals, codes and guidelines relating to treatment and disposal of sewage and trade effluents as well as for stack gas cleaning devices, stacks and ducts;
- Disseminate information in respect of matters relating to water and air pollution and their prevention and control;
- Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and
- Perform such other function as may be prescribed by the Government of India.

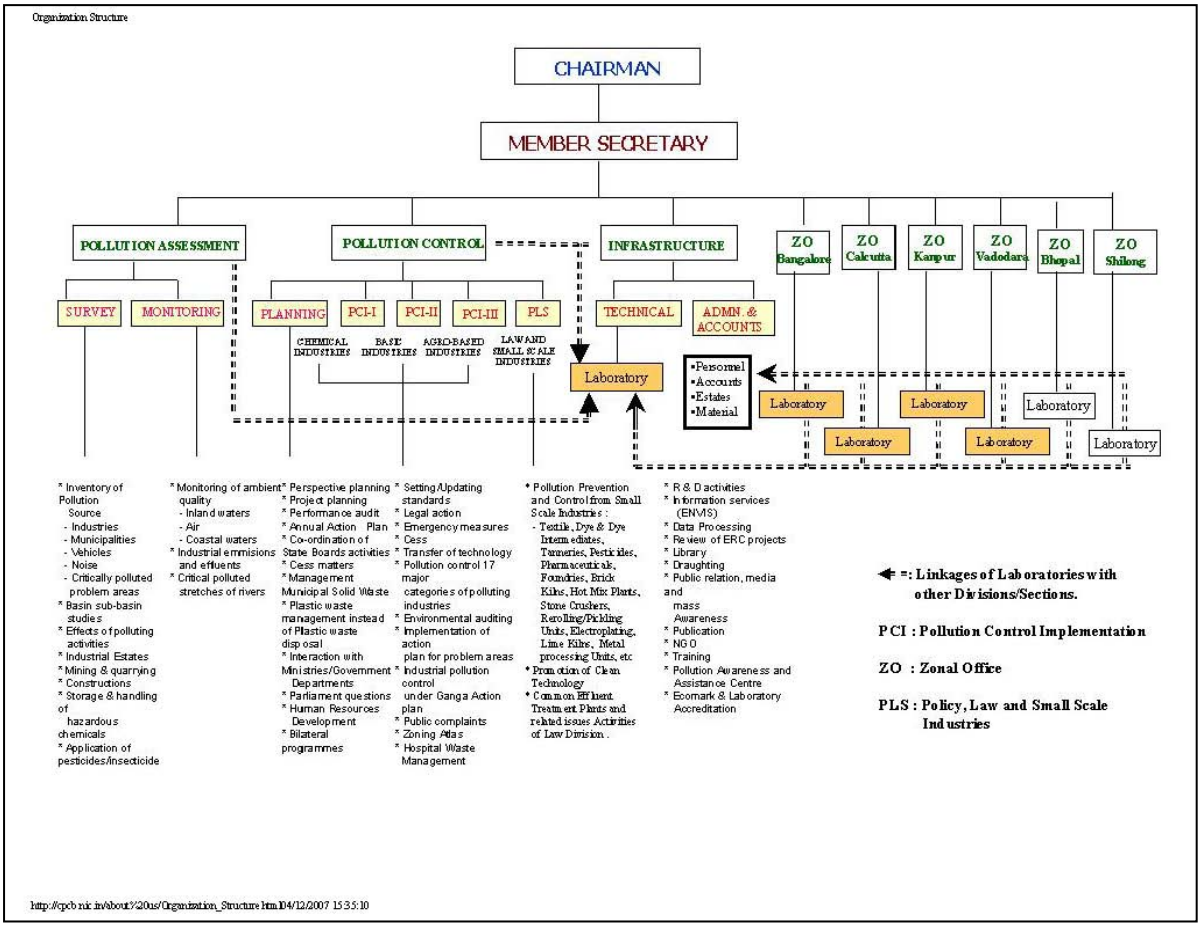
The functions of the Central Board as State Boards for the Union Territories are:

- Advise the Governments of Union Territories with respect to the suitability of any premises or location for carrying on any industry which is likely to pollute a stream or well or cause air pollutions;

- Lay down standards for treatment of sewage and trade effluents and for emissions from automobiles, industrial plants, and any other polluting source;
- Evolve efficient methods for disposal of sewage and trade effluents on land; develop reliable and economically viable methods of treatment of sewage, trade effluent and air pollution control equipment;
- Identify any area or areas within Union Territories as air pollution control area or areas to be notified under the Air (Prevention and Control of Pollution) Act, 1981;
- Assess the quality of ambient water and air, and inspect wastewater treatment installations, air pollution control equipment, industrial plants or manufacturing process to evaluate their performance and to take steps for the prevention, control and abatement of air and water pollution.

As per the policy decision of the Government of India, the CPCB has delegated its powers and functions under the Water (Prevention and Control of Pollution) Act, 1974, the Water (Prevention and Control of Pollution) Cess Act, 1977 and the Air (Prevention and Control of Pollution) Act, 1981 with respect to Union Territories to respective local administrations. CPCB along with its counterparts State Pollution Control Boards (SPCBs) are responsible for implementation of legislations relating to prevention and control of environmental pollution.

Fig. 9.2: Organizational structure of the CPCB



9.2.2 The State Pollution Control Boards

Among the various programmes implemented by the State Pollution Control Boards, the following are relevant in the context of water quality [4]:

- Pollution control in 17 categories of highly polluting industries
- Pollution control from industries discharging waste water into rivers and lakes
- Inventorization of pollution industries in the State and ensuring their compliance to the Pollution control norms
- Restoration of environmental quality in critically polluted areas
- Monitoring of water and ambient air quality in the States

As an example of a State Pollution Control Board's objectives, mandate etc, the example of the Tamil Nadu State Pollution Control Board (TNPCB) is given below [5]:

Objective: The objective of TNPCB is to control, prevent and abate pollution of streams, wells, land and atmosphere in the State to protect the environment from

any degradation by effective monitoring and implementation of pollution control legislations.

Organizational Structure:

Head Office	**Chennai**
Board Members	15
Staff Strength	
Chairman	1
Member Secretary	1
Engineering Staff	143
Scientific Staff	182
Administrative Accounts And Misc.	404
Total	731
District Environment engineer offices	20
Assistant Environment Engineer offices	5
Laboratories	
Advanced Environment Laboratories	3
District Environment Laboratories	10
Mobile Environment Laboratory	1
Vehicle Emission Monitoring station	
Chennai	3

Functions:
The main function of the TNPCB is as follows:

- To plan a comprehensive programme for the prevention, control and abatement of water and air pollution.
- To encourage, conduct and participate in investigations and research relating to problems of water, land and air pollution and its prevention, control and abatement thereof.
- To inspect sewage and trade effluent treatment plants for their effectiveness and review plans, specifications for corrective measures.
- To lay down, modify or annul effluent standards for the sewage/trade effluents and for the emissions of air pollutants into the atmosphere from the industrial plants and automobiles and for the discharge of any air pollutant into the atmosphere from any other source.
- To evolve best economically viable treatment technology for sewage and trade effluents.
- To evolve efficient methods of disposal of sewage and trade effluent on land.
- To monitor the generation, transportation, treatment, storage and disposal of hazardous wastes.
- To identify and monitor the isolated storage of hazardous chemicals.
- To collect samples of sewage/trade effluents and emissions of air pollutants and to analyze the same for specific parameters.
- To collaborate with Central Pollution Control Board in organizing the training of persons engaged or to be engaged in programmes relating to prevention, control

or abatement of water/air pollution and to organize mass education programme relating thereto.

Functions of the various branches:

S. No.	Various Branches of the Board	Functions
1.	**Head Office at Chennai**	1.Overall Control of Field Offices and Laboratories 2.Technical/Consent Wing 3.Legal Wing 4.Hazardous Waste Management 5.Biomedical Waste Management 6.Municipal Sold Waste Management 7.Cess Section 8.Ozone Cell 9.Planning and Development Section 10.Monitoring of Highly Polluting Industries 11.Environment Awareness Cell 12.Environmental Training 13.All Environmental Issues
2.	**District Offices**	1.Monitoring of Industrial Pollution. 2.Inspection and Sample Collection 3.Investigation of Complaints 4.Issue/Renewal of Consent to Orange and Green category industries 5.Renewal of consent for Red category small industries 6.Issue of Show Cause Notice to erring Industries 7.Legal Proceedings District Environmental Committees 8.Public Hearing Panels 9.Other District Level Issues
3.	**Laboratories**	1.Analysis of Effluent /water Samples 2.Analysis of Source Emission Samples 3.Research in abating Pollutants 4.Vehicle Emission Monitoring 5.Monitoring of Water Sources 6.Coastal Monitoring 7.Noise Level Monitoring 8.Monitoring of Air Quality and related projects.

- TNPCB issues consent to new industries in two stages. Consent to establish is issued depending upon the suitability of the site before the industry takes up the construction activities and consent to operate is issued after installation of pollution control measures by the unit to satisfy the standards.
- TNPCB issues show cause notices, takes legal actions and also issues directions for closure, stoppage of power supply, water supply etc., against erring industries / agencies for non-compliance of pollution control legislations, conditions and standards.
- TNPCB has delegated the power to the field officers for close monitoring. The Joint Chief Environmental Engineer/ District Environmental Engineers / Assistant

Environmental Engineers are empowered to issue/renew consent to orange and green category industries and to renew for red small category industries. They are also empowered to issue show cause notices to all the industries.

- TNPCB plays a catalytic role in the implementation of Common Effluent Treatment Plants (CETPs) for small scale units like tanneries, textile dyeing units etc., located in clusters.
- TNPCB is taking effective steps for safe disposal of hazardous wastes and has completed the inventory of hazardous waste generating units and also identified sites for disposal of hazardous wastes.
- TNPCB creates environmental awareness in the State through the Environmental Training Institute, Environmental Awareness Cell, Environmental Awareness Programme, Environmental Pavilion constructed at the Periyar Science and Technology Centre (Chennai), NGO Cell, Publishing of Newsletters/Pamphlets on environmental issues, etc.

In general, the State PCBs enforce the following laws:

- Water (Prevention and Control of Pollution) Act 1974
    - Fix tolerance limits for trade effluents, consent fee for Red, Orange and Green Industries based on their fixed assets
- Water (Prevention and Control of Pollution) Cess Act, 1977
- Environment (Protection) Act, 1986 and relevant rules, notifications under the act
    - EIA Notification
- National Environmental Appellate Authority Act:
- Siting of new industries**:** Guidelines have been evolved for siting of New Industries prescribing the distance from sensitive areas and restricting certain industries within 1 km from specified water sources.

    - For example, in the state of Tamil Nadu, the Government in G.O. Ms. No.213/E&F(EC-I) Dept. ECII/ dt . 30.3.89 has imposed restriction of certain highly polluting industries within 1km of specified water sources. The restriction has further been made stringent as 5 km in respect following water sources as per G.O. Ms. No.127 E&F Dept(EC3)dt.8.5.98 read with G.O. Ms (ID) No, 223 E&F(EC3)Dept dt 2.9.98: 1. Cauvery and its tributaries 2. Pennaiyar, 3. Palar , 4. Vaigai , 5. Tamirabarani

The State Pollution Control Boards receive funds from the concerned State Governments and from the Central Ministry of Environment & Forests through reimbursement of Water Cess (upto 80%) collected by the respective State Boards. In addition, the State Boards receive fees for processing for applications from the industries for issuing consent in regard to discharge of effluent and emissions.

The State Pollution Control Board also process documents for EIA clearance. The State EIA Authority (SEIAA) is notified by a Central Government Order. The SEIAA is a quasi-judicial authority and the State Level Expert Appraisal Committee (SEAC) is the apex technical body for evaluation of Environmental Impact Assessment Report and Environmental Management Plan of any proposed industry / developmental activities.

9.2.3 Environmental Authorities

In addition to Pollution Control Boards, six Environmental Authorities [6] have been constituted under the Environment (Protection) Act 1986, including the National Environment Appellate Authority. The authorities of relevance to coastal areas are:

- The Central Ground Water Authority: For the purpose of regulation and control of Ground Water Management and Development (Constituted on 14.1.1997);
- Aqua Culture Authority: To deal with the situation created by the shrimp culture industry in the Coastal States and Union Territories (Constituted on 6.2.1997);
- Loss of Ecology (Prevention and Payment of Compensation) Authority for State of Tamil Nadu: To assess the loss to the ecology and environment in the affected areas and also identify the individuals and families who have suffered because of the pollution and assess the compensation to be paid to the said individuals and families (Constituted on 30.9.1996);
- National Environment Appellate Authority,1997

9.3. Ministry of Earth Sciences [7]

The mandate of the Ministry of Earth Sciences (formerly Ministry of Ocean Development) is to look after Atmospheric Sciences, Ocean Science & Technology and Seismology in an integrated manner. The Integrated Coastal and Marine Area Management Project Directorate (ICMAM PD), an attached office of Ministry of Earth Sciences (MoES), Government of India is located in the campus of the National Institute of Ocean Technology at Chennai. Its mission is ‘Developing and improving capability to understand the critical coastal parameters, processes and phenomena, which have significant societal, economic and environmental benefits’ and ‘Providing scientific and technical support for coastal states for implementing the ICMAM concept and ecosystem-based management for sustainable use of resources’. It has brought out publications such as on the waste assimilation capacity for certain

estuaries and marine ecotoxicology. ICMAM PD is also carrying out the COMAPS project.

9.4. COASTAL AQUACULTURE AUTHORITY [8]

Coastal aquaculture is the culturing, under controlled conditions in ponds, pens, enclosures or otherwise, in coastal areas of shrimp, prawn, fish or any other aquatic life in saline or brackish water. The Coastal Aquaculture Authority was set up after the passing of the Coastal Aquaculture Authority Act in 2005. Inter alia, the authority makes regulations for the construction and operation of aquaculture farms within the coastal areas and inspects coastal aquaculture farms with a view to ascertaining their environmental impact caused by coastal aquaculture. Besides these, the Coastal Aquaculture Authority is also mandated to perform various functions of which the following are particularly relevant in the context of this report:

- To ensure that the agricultural lands, salt pan lands, mangroves, wet lands, forest lands, land for village common purposes and the land meant for public purposes and national parks and sanctuaries shall not be converted for construction of coastal aquaculture farms so as to protect the livelihood of coastal community;
- To survey the entire coastal area of the country and advise the Central Government and the State/ Union territory Governments to formulate suitable strategies for achieving eco-friendly coastal aquaculture development;
- To advise and extend support to the State/ Union Territory Governments to construct common infrastructure viz., common water in-take and discharge canals by the coastal aquaculture farms and common effluent treatment systems for achieving eco-friendly and sustainable development of coastal aquaculture.

9.5. Indian Coast Guard [9]

The Indian Coast Guard is the principal agency for enforcement of provisions of all national enactment in force in the maritime zones of India and provides following services to the Nation and marine community:

- Ensuring safety and protection of the artificial islands, offshore installations and other structure in our maritime zones
- Providing protection to fishermen and assistance to them at sea while in distress.
- Preservation and protection of our maritime environment including prevention and control of maritime pollution.
- Assistance to the Department of Custom and other authorities in anti-smuggling operations.

- Enforcement of MZI Acts.
- Initiating measures for the safety of life and property at sea.

Oil Spill Response

The Director General Coast Guard was designated as the Central Coordinating Authority (CCA) to implement the Oil Spill Response Plan, and coordinate response activities in the event of an oil spill at sea. The Ministry of Shipping, the Department of Ocean Development, the Ministry of Petroleum and Natural Gas, oil companies, Port authorities, and maritime states are also stakeholders in the Plan who will act independently or in co-ordination with the Coast Guard in an oil response scenario in the maritime zones of India. Accordingly, a National Oil Spill Disaster Contingency Plan has been developed with an updated version in 2006. The National Oil Spill Disaster Contingency Plan (NOS-DCP) stipulates the organisational and operational details to effectively combat a national oil spill contingency. This plan is intended to delineate functions of various concerned departments and agencies for the operational responsibility to marine incidents which could result due to spillage of oil into water. The plan also provides the frame work of co-ordination of integrated response by various government departments and agencies to protect the environment from the deleterious effects of pollution by oil.

9.6. Ministry of Shipping [10]

Ministry of Shipping was formed in 2009 by bifurcating the erstwhile Ministry of Shipping, Road Transport and Highways into two independent ministries. The Ministry of Shipping encompasses within its fold shipping and ports sectors which include shipbuilding and ship-repair, major ports, national waterways, and inland water transport.

India's long coastline forming one of the biggest peninsulas in the world is serviced by 12 government and 1 corporate major ports and 185 notified minor and intermediate ports. Six of the major ports are located on the east (Bay of Bengal) coast of India. The classification of Indian ports into major, minor and intermediate has an administrative significance. While the Central Shipping Ministry administers the major ports, the minor and intermediate ports are administered by the relevant departments or ministries in the nine coastal states. Private-sector participation in ports has increased tremendously. Some ports have been declared as captive ports at the specific request of private companies / entrepreneurs for their captive use. At the captive ports, the infrastructural facilities are developed by the company / entrepreneur concerned.

The port officer (or harbour master as the case may be) is designated as the Conservator of the Port and by virtue of the Indian Ports Act, 1908, is to take cognizance of issues such as bilge water dumping in port premises can issue a

notice on the offending vessel or take action and recover expenses according to procedure.

Directorate of Shipping [11]

The Directorate General of Shipping, India deals with implementation of shipping policy and legislation so as to ensure the safety of life and ships at sea, prevention of marine pollution, promotion of maritime education and training in co-ordination with the International Maritime Organization, regulation of employment and welfare of seamen, development of coastal shipping, augmentation of shipping tonnage, examination and certification of Merchant Navy Officers, Supervision and Control of the allied offices under its administrative jurisdiction. It also implements appropriate legislation such as the Merchant Shipping Act, 1958 and the rules made under the Act such as The Merchant shipping (Prevention of Pollution of the Sea by Oil) Rules, 1974 and The Merchant Shipping Rules, 2010.

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1 Information largely from the Annual Report of the CPCB: 2006-2007. www.cpcb.nic.in
2 CPCB – Introduction. http://www.cpcb.nic.in/Introduction.php
3 CPCB Website: www.cpcb.nic.in
4 CPCB Website – FAQ: http://www.cpcb.nic.in/faq1.php#2
5 TNPCB Website: http://www.tnpcb.gov.in
6 Parivesh, 2002. http://cpcbenvis.nic.in/newsletter/legislation/ch3dec02a.htm
7 Ministry of Earth Sciences : www.moes.gov.in
8 Coastal Aquaculture Authority: http://www.caa.gov.in
9 Indian Coast Guard: http://www.indiancoastguard.nic.in/
10 Ministry of Shipping: http://shipping.gov.in/
11 Directorate of Shipping: http://dgshipping.com/

CHAPTER 10: GAPS, PRIORITY ACTIONS AND RECOMMENDATIONS

10.1 Gaps in Information/ Data on Coastal Pollution

Pollution of oceans and coasts is rapidly becoming a major problem world-wide and the Indian coast is no exception. The coastal waters of the Indian maritime states are under the constant threat of pollution from a number of land based sources apart from marine sources. Despite knowing the effects of land-based pollution on the coastal waters, direct and indirect discharge of wastes and effluents from untreated domestic and industrial sources continue reach the coastal waters.

Some of the important information gaps for prudent management of the coastal/ marine environment in India include:

- Seasonal and annual variation in pollution loads from land-based activities,
- Extent of contamination of coastal sediments as a result of land based activities,
- Coverage, treatment types, and discharge data for urban sewerage systems to determine effectiveness and efficiencies of these systems.
- Knowledge about the chemical, physical, hydrological and biological processes taking place in estuaries, marine habitats, coastal waters and the interdependencies among marine resources in the Indian context.
- Impact of coastal aquaculture on mangroves and other coastal habitats,
- Coastal erosion due to human activities
- Ballast water disposal into coastal waters and its impact as well as information on Invasive Alien Species
- Oil pollution from ports, oil rigs as well as spills during transportation
- Marine Litter related data
    - A scientific study in Nicobar Islands revealed that floating debris ranging from disposable plastic cups to pressurized containers to automobile parts were brought by surface currents.
    - Ship-breaking industry as a source of marine debris needs to be quantified.
    - Fishing-related debris- Dumping, wastes from ships, boat platforms
- Information on bioaccumulation, bioconcentration, biomagnification and trophic transfer of critical pollutants

10.2 Priority Actions to address gaps

Some of the issues mentioned above are already being addressed at different levels. The CPCB has a regular system of monitoring surface waters within the country. As described in Chapter 4, India is undertaking a systematic long-term study of pollutants, in a regional context, and their effects on biota, under the COMAPS Programme as a part of the Ministry of Earth Sciences, Government of India. Levels and distribution of contaminants in the water column, sediments and in benthos, are being measured and monitored over long periods of time. [1]. A ballast water monitoring system is already underway.

Clean up of identified rivers and lakes are being taken up under various programmes for restoration of lakes and rivers. Common Effluent Treatment Plants for industries and Sewage Treatment Plants for domestic wastewater are being set up in many places to reduce the pollution pressure on receiving water bodies. With respect to ballast water, the National Institute of Oceanography (NIO) has completed work related to port biological baseline surveys, ballast water risk assessment and identification of ballast water discharge sites for a few ports. Through this program NIO also developed a user friendly and self validating e-form for reporting ships' ballast water history, which is an essential requirement for conducting ballast water risk analysis [2].

The National Centre for Sustainable Coastal Management (NCSCM) at Chennai and the National Centre for Marine Biodiversity (NCMB) at Jamnagar, have been set up by the Ministry of Environment and Forests. The NCSCM has a ‘Knowledge Management Division’ which is expected to address the information gap with respect to data on coastal pollution, coastal erosion and shoreline change. The NCMB aims at developing a repository of information on marine life to facilitate marine biodiversity conservation and management in India.

10.3 Monitoring systems

With the widespread availability of satellite imagery, synoptic monitoring tools of moored buoys and remote sensing by satellites and by acoustics must be used where possible. In recent times, Geographic Information System is used as an effective tool to display trends in pollution and to further predict scenarios from the available information and database. The Indian National Centre for Ocean Information Services (INCOIS) [3] has been using these newer systems for collecting data on temperature and salinity, which are mainly for climate forecasting. The availability of primary data from the various maritime states of India with reference to pollution and pollution-control related activities needs to be strengthened. Some

suggestions to improve information available to evaluate coastal water quality and monitor trends within the region can be undertaken by:

- Upgrading the existing monitoring system in accordance with the protocol of the Central Pollution Control Board and EPA 1986,
- Reviewing and if possible, improving the accuracy of water quality model forecasts.
- Provide better access to water quality monitoring data by:
    - Assembling existing data resources of pollution along the Indian coast
    - Determining flux of pollutants from oceanic sources to coastal waters
    - Regularly updating water quality monitoring information/ data via the INCOIS/ CPCB websites
    - Exploring the feasibility of providing real-time data on the website
- Publishing water quality information in the local language as newsletters and provide news updates on coastal water quality issues.
    - Currently the CPCB through the various state/union territory pollution control boards has developed continuous monitoring and display for some air pollutants as well as for noise. A system needs to be developed on similar lines especially near sensitive coastal ecosystems.
- Establishing "Sentinel Sites" for continuous monitoring of sensitive and pristine coastal waters to better understand the effects of climate change, and other land based pollution, as reference sites for comparative studies

10.4 Gaps in Legislation and Policies

The regulatory and institutional decision-making framework for environmental management and protection in India, both at the National and State level, is embodied in a number of major acts of the Parliament. These have been discussed earlier in Chapter 8. In fact, there is really no dearth of legislation on controlling pollution of coastal waters. However, what is needed is the linking of all the different legislations so that there is no overlap and no confusion over responsibilities of implementation.

Standards have been set for water quality of various types and these are listed under various Rules under the EPA 1986. A major gap in legislation is the lack of standards for sediment quality such as concentrations of nutrients and trace metals in sediments underlying coastal waters. This aspect is important due to the deleterious effects that can be caused by resuspension of sediments as well as release of chemical compounds from the sediment-bound fractions. For example, increasing hypoxic/ anoxic conditions of bottom waters may result in the release of nutrients especially phosphorus into the water column that can stimulate algal blooms.

With respect to policy gaps, India has a National Environment Policy but a country with a coastline of over 8000km should also have a Coastal Policy which should take into cognizance the various coastal activities to ensure integrated development as well as protection of the coastal environment.

The other gap with respect to legislation is implementation. Lack of enforcement is often because of the insufficient manpower, budgetary constraints and large number of industries that need to be monitored. It takes time for the institutional structure to respond to violations. Procedural delays as well as the relatively insignificant penalties mean that by the time the violations are controlled, the damage to the environment is irreparable. The CRZ 2011 and the EPA 2006 have brought a lot more clarity into the environmental clearance processes by providing timelines for various activities. Clear post-project monitoring regimes are to be specified in each environment management plans. Similar timelines should not just be indicated but implemented with legislative sanction in case of pollution violations.

10.5 Implementation issues (capacity constraints both human, technical/ infrastructure)

The Indian government proposes to introduce the Polluter Pays Principle as part of the amendment to Environment Protection Act. This implies that the polluter should bear these costs in order to achieve and maintain an "acceptable state of environment" which is determined by the Government of India. India has recently launched a green court to make polluters pay damages as it steps up its policing of the country's environmental laws. It is also expected that all the States and Union Territories of India will implement the Integrated Coastal Zone Management (ICZM) Plan, which includes combating coastal pollution as one of the most significant aspects of coastal management. Some of the gaps in implementation include:

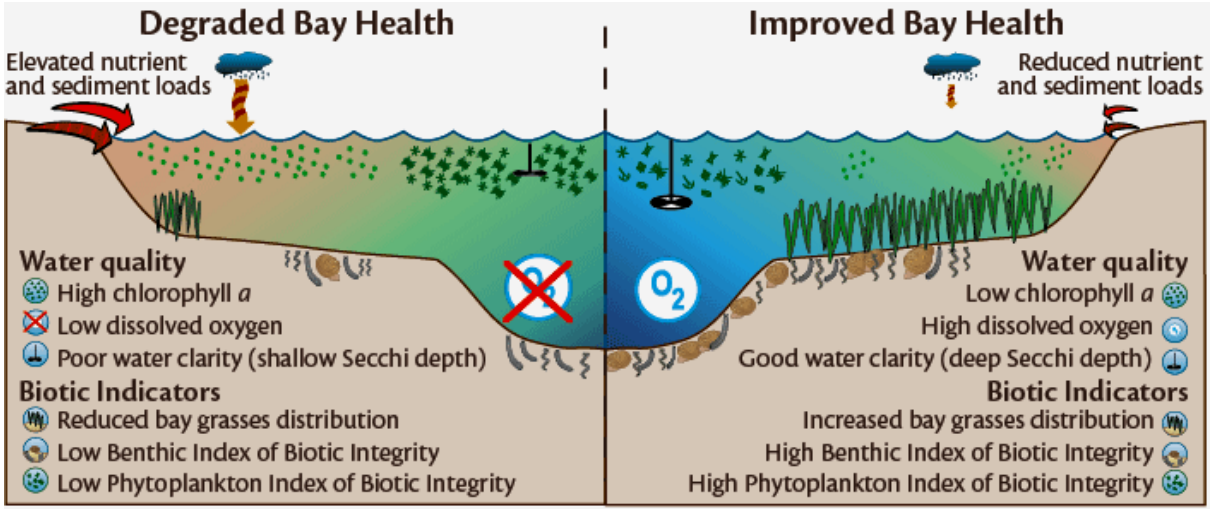
- Need for Spatial Data for GIS in Coastal Areas
- Building capacity for officers of the State/ UT Governments towards implementation and enforcement of the Environment Protection Act, as stipulated by the Ministry of Environment and Forests, Government of India

10.6 Recommendations: Report Card of pollution status to public

The concept of a "Report Card" that is a useful and basic information for the public is not known in India and would be a new approach to inform the public of coastal pollution status periodically. A brief description of the purpose and usefulness of a report card is given below.

Report Card approach for assessing and forecasting ecosystem status [4,5]

Ecosystem health report cards are an effective means of tracking and reporting the health of a waterway at both local and regional scales. River/estuary/ bay health can be affected by elevated nutrient and sediment loads, resulting in water quality and biotic (biological) degradation. For the report card, river/ estuary/ coastal health is defined as the progress of six indicators towards established ecological thresholds. The three water quality indicators are chlorophyll a, dissolved oxygen, and water clarity: and the three biotic indicators are aquatic grasses (submerged aquatic vegetation), Benthic Index of Biotic Integrity (soft bottom only), and Phytoplankton Index of Biotic Integrity.



The goal of improved coastal health through nutrient and sediment reductions should result in the indicators meeting established ecological thresholds. Threshold values must be established for each indicator based on published scientific literature and technical reports. Measuring progress towards thresholds allows for both combining diverse indicators into indices and comparison between different regions. Monitoring data are assessed against the threshold values by determining the percentage of samples passing the thresholds over the period of interest.

Water clarity is the most visible indicator of water quality. Suspended material such as sediment or algae in the water can make it appear murky or cloudy. Murky water blocks sunlight from penetrating through the water and reaching underwater grasses, which need light to grow. Sediment enters the river and estuaries with each significant rainfall, as storm water runoff carries dirt and other material. Sediment can also come from eroding river banks, poorly managed construction sites, and agricultural runoff. Algae and other biological material in the water column also

decrease water clarity. Algae both block and absorb sunlight, further decreasing the light available for underwater vegetation.

Water clarity is measured with a Secchi disk, which is lowered into the water until it can no longer be seen.
Threshold: ≥ 1.0 meter Secchi depth

Dissolved Oxygen: Low dissolved oxygen levels are a symptom of an ecosystem out of balance. The existence of "dead zones" means there are fewer habitats for aquatic life to thrive. To improve oxygen levels, the sources of nutrient pollution need to be controlled. Upgrading local wastewater treatment plants as well improving storm water management systems has to be done. Nutrient pollution coming from agricultural runoff also needs to be controlled.

Dissolved oxygen concentration fluctuates during the day, as algae and other plants produce oxygen through photosynthesis. Levels are lowest at night, when photosynthesis stops and fish, crabs, and other aquatic animals consume existing oxygen. Areas with insufficient oxygen are known as "dead zones."

Oxygen data would be measured against a **threshold of 5 mg/l.**

Nutrient pollution, in the form of excess nitrogen and phosphorus, is the major driver of the river/estuaries poor water quality. The natural cycles of nitrogen and phosphorus have been drastically altered by human activities. Nutrients act as fertilizer and spur unchecked algae growth. Nutrients enter our rivers/estuaries from many sources. Another source of nitrogen is atmospheric deposition (from air pollution).

Threshold:
Total Nitrogen ≤ 0.65 mg/l
Total Phosphorus ≤ 0.037 mg/l

Chlorophyl *a* is a green pigment found in most plant life, including algae or phytoplankton. Measuring chlorophyll *a* concentrations is the best way to determine how much algae are in the water. Through photosynthesis, phytoplankton produce oxygen using sunlight. Phytoplankton is also the primary food source for many species, including oysters, clams, mussels, and many fish. It is, therefore, a critical part of the food web. However, nitrogen and phosphorus in wastewater act as fertilizer resulting in phytoplankton communities growing out of control, creating algal blooms. Algalt blooms block light from reaching underwater grasses and consume oxygen at night,. When blooms die off, their decomposition also uses up oxygen. Algal blooms are often the cause of fish kills, since they may use up all the

available dissolved oxygen in the water, leaving none for other aquatic life. Some algal species can be toxic to humans.

Threshold:
≤ 6.2 ug/l (spring), ≤ 7.7 µg/l (summer)

The monitoring sites can be rated on an **Index of Biological Integrity (IBI).** The IBI is a scientific tool used to identify and classify waterway health. Healthy rivers/ estuaries support a diverse community of aquatic life, including fish, shellfish, and benthic organisms. The IBI measures ecological complexity by analyzing such factors as species diversity in a sample.

IBI Scale
1.00-1.99 Very Poor
2.00-2.99 Poor
3.00-3.99 Fair
4.00-5.00 Good

Ecosystem health report cards can be an effective means of tracking and reporting the health of a waterway at both local and regional scales. A report card is now being developed for various coastal hotspots in India for the sake of the science and management community in order to provide a transparent, timely, and geographically detailed annual assessment of coastal waters and its ecosystem habitat health.

[1] Monitoring of Marine Pollution through Coastal Ocean Monitoring and Prediction System (COMAPS) Programme: http://www.icmam.gov.in/comaps/index.html

[2] NIO. Ballast water management programme gets extended to other 8 major ports of India. http://www.nio.org/index/option/com_newsdisplay/task/view/tid/4/sid/23/nid/267

[3] INCOIS www.incois.gov.in

[4] http://ian.umces.edu/pdfs/ecocheck_newsletter_264.pdf

[5] http://www.eco-check.org/reportcard/chesapeake/2009/methods/

Chapter 11: Summary and Conclusions

The near shore coastal and marine environment of India is the most biologically productive and economically important zone. However, a variety of Land-Based Activities (LBA) have resulted in the degradation of the quality of near shore waters and ultimately diminishing the utility of the marine resources.

The inventory given in this national assessment is the most comprehensive characterization of pollutant discharges developed for the Bay of Bengal region. This can serve as a valuable status report for national and transboundary management of coastal pollution. It provides coastal managers throughout the Bay of Bengal region with an overall picture of the types and amounts of pollutant discharges generated by land-based activities. The report provides the current status of coastal pollution and based on the past trends, evaluates future relative contributions of point and nonpoint pollutant discharges along the coast of India.

The information provided in this report facilitates a detailed understanding to better target pollution control strategies and to identify the coastal hotspots with the greatest impact on pollution problems. The data are useful in setting priorities regarding how to manage and protect individual coastal hotspots and the adjacent estuaries along the Bay of Bengal coast of India, and can contribute to a better understanding of the impact that point and nonpoint source discharges have on water quality.

Land-based activities are the major sources of problems and threats facing the oceans and marine ecology, especially coastal areas, except for the effects of fishing and the threats posed by global climate change. In the past decade, there have been some notable successes in curbing the negative impacts of land-based activities on the marine and coastal environment. Unfortunately, from a global perspective, the degradation of the oceans and coastal areas has continued, and in many places even intensified. Degradation is much more severe in the coastal areas than in the open ocean. The priority action areas for the control of LBAs with respect to pollution to improve the quality of the marine environment in context of India are (GESAMP 2001):

- To focus management effort on sewage, nutrients (especially nitrogen);
- To prevent habitat destruction and loss of biodiversity by the enforcement of legal, administrative and economic measures appropriate to local circumstances; and
- To integrate the management of coastal areas and associated watersheds.

Priority actions

The priority for implementation would be general actions and issues specific actions for addressing pollution of marine waters from land based activities. The general actions required can be listed as:

- Preparation of coastal zone management action plan (CZMP), most of the coastal states have been advised to prepare CZMP, however, very few states have approved CZMP as of date;
- Identify and map critical and sensitive coastal habitats, including those already lost or severely impacted; and
- Apply integrated coastal area management practices to coastal planning and development.

The majority of coastal environmental problems are multi-causal in origin such that exact causes are often difficult to specify. While incomplete knowledge leads to uncertainty in the decision-making process, coastal resources managers have tools for managing this uncertainty and for addressing major causes such as land-based sources of pollution. Based on this review of information and data on coastal pollution, four factors are considered critical when integrating scientific knowledge into public policy-making:

- the limitations of science;
- scientific uncertainty;
- the importance of communication;
- the role of politics and stakeholders.

It is important to develop a substantial adaptive management strategy for the use of risk assessment and risk management (RA/RM) together with Integrated Coastal Management (ICM) for assessing coastal pollution from land based sources. By combining these frameworks, a comprehensive coverage of the marine and coastal environments and the associated land-based and sea-based issues can be obtained. The magnitude of the impacts of land-based sources of pollution simply dwarfs all other regional drivers. There are many environmental challenges in the marine and coastal areas of the Bay of Bengal region and the prime intent is to prevent and mitigate pollution from land based activities. Addressing pollution from land-based sources raises particular challenges for developing States, due to the wide variety of possible pollutants and the fact that pollution originates from both point and non-point sources. Scientific knowledge must therefore be coupled with an understanding of modern approaches to ICM, as well as policy perspectives on how to mainstream marine and coastal issues into national development frameworks.

Bangladesh, India, Indonesia, Malaysia, Maldives, Myanmar, Sri Lanka and Thailand are working together through the Bay of Bengal Large Marine Ecosystem (BOBLME) Project and to lay the foundations for a coordinated programme of action designed to improve the lives of the coastal populations through improved regional management of the Bay of Bengal environment and its fisheries.

The Food and Agriculture Organization (FAO) is the implementing agency for the BOBLME Project.

The Project is funded principally by the Global Environment Facility (GEF), Norway, the Swedish International Development Cooperation Agency, the FAO, and the National Oceanic and Atmospheric Administration of the USA.

For more information, please visit www.boblme.org