Status of Coastal Habitats and its Management in India

S.M. Marale [#1], R. K. Mishra [*2]

[#*]*Society of Integrated Coastal Management, New Delhi, India*
[1]maralesanjay@gmail.com [2]rajanimishra@yahoo.com

***Abstract*- In supersession of Coastal Regulation Zone (CRZ) 1991, with a view to ensure livelihood security to the fisher and other communities living in coastal areas, to conserve and protect coastal stretches the Government of India imposed CRZ notification 2011. The areas such as mangroves, corals, mudflats, national marine parks, salt marshes, turtle nesting grounds, horse shoe crab habitats, sea grass beds, nesting grounds of birds, and archeology and heritage sites were considered as an ecologically sensitive area (ESA) where setting and expansion of industries, operations or processes are restricted. This article aims to critically observe the status of coastal habitats in the light of coastal threats such as habitat loss, coastal pollution and nutrient load, climate change, overexploitation and invasive alien species. Some remedial measures and recommendations for conservation of coastal habitats including strengthening CRZ rules were suggested.**

***Keywords*- Coastal Habitats; Coastal Regulation Zone; Management; India; Livelihood**

I. INTRODUCTION

The dynamics of population and the management of environmental resources are closely related concerns confronting our world. Whether we live in rural or urban, developing or developed regions, we need to understand and deal with the linkages between the status of society for e.g., population, socio-economic development, physical health, quality of life and the condition of the natural environment, fresh water, soil, biodiversity etc. [1].

Even though the integrated coastal management (ICM) initiatives are growing worldwide the lessons learned from these initiatives are generally undocumented and the efficiency and effectiveness of learning from these initiatives is being compromised [2]. There are two basic elements for environmental management. The first deals with the construction of a solid basis for understanding environmental change, the second is of a much broader nature can be exemplified by the integrated management of river basins and coastal areas [3]. Present paper gives emphasis on understanding the changes taking place in coastal environment by using coastal habitats as an indicator rather than going for broader areas of management of integrated river basin and coastal area management.

II. GEOMORPHOLOGY OF INDIAN COAST

The coastal geomorphology of India is divided into offshore features, shore features, coastal features and littoral geomorphology in relation to human activities and problems [4]. India has about

7,500 km long coastline. The Economic Exclusive Zone (EEZ) extends up to 2.02 million sq.kms and 14 major rivers, 44 medium rivers and 162 minor rivers discharge vast quantity of water and sediments to the ocean [5]. The major rivers that cut across the coast are the Ganges, Brahmaputra, Krishna, Godavari, and Cauvery on the east coast, and Narmada and Tapti on the North West coast.

The continental shelf of India is very wide on the west coast with about 340 km in the north, tapering to less than 60 km in the south. Considering geomorphic characteristics, the Indian coast is divided into two categories, namely coasts on the west coast of India and coasts on the east coast of India. The west coast of India is further divided into Gujarat coast, Maharashtra, Goa and northern Karnataka coast, Southern Karnataka and Kerala coast based on their geomorphologic distinctions. The coastal area of Gujarat is the largest in the country with about 28, 000 sq.km. The east coast of India is divided into Tamil Nadu and Pondicherry in south, marked by deltas as major landforms due to the Cauvery River and its tributaries.

The coastline of Andhra Pradesh, mainly the deltaic coast, is 640 km long and comprised of bays, creeks, extensive tidal mudflats, spits, bars, mangrove swamps etc. The Orissa coast is a site of deposition formed and controlled by Mahanadi and Brahmni deltas, mud flats, spits, bars, beach, ridges, creeks, estuaries etc. The west Bengal coast represents a typical deltaic strip with almost a flat terrain. The Hooghly and its distributaries form the conspicuous drainage system and form an estuarine delta.

The Sundarban is one of the largest single block of halophytic mangrove systems, about 1430 km^2, one of the largest mangroves systems of the world need a special mention [6]. The 42 islands of the Gulf of Kuchchh are the northern most coralline or sandstone based islands in western Indian Ocean. Lakshadweep islands the northern most islands of the Laccadive-Chagos ridge located about 200-400 km off the southwest coast of India. Gulf of Mannar islands a chain of 21 islands between southeast India and Sri Lanka have only shrub as vegetation and occasionally patches of mangroves. The Seagrass beds associated with reefs have been important feeding grounds for the Dugong species [7].

The current inventory, as seen from the Ocean Biogeography Information System, stands at 34,989 species in Indian Ocean [8]. Indian coasts have large variety of sensitive ecosystems-sand dunes, coral reefs, sea grass beds, wetlands, mudflats, rocky and sandy shores along with backwater estuaries and coastal lagoons that support the rich and diverse flora and fauna [9]. Among the continental nations, the most comprehensive account of coastal marine biodiversity is that from India, which reports 15,042 species followed by Indonesia (10,855 species). Estimates suggest that 3,959 species of flora and fauna is associated to the mangrove habitats in India [10].

III. COASTAL REGULATION ZONE IN INDIA

For the purpose of conserving and protecting the coastal areas and marine waters, the Coastal Regulation Zone (CRZ) area is classified as CRZ I, CRZ II, CRZ III and CRZ IV. The areas that have been developed up to or close to the shoreline are included in CRZ II, generally referred as the area within the municipal limits, CRZ III includes areas that relatively undisturbed, less built up and rural areas, and CRZ IV includes the water area from the Low Tide Line to twelve nautical miles on the seaward side. The areas that are ecologically sensitive and the geomorphologic features which play a role in maintaining the integrity of the coast are referred as CRZ I. Fourteen habitats are considered under the CRZ for its conservation on priority as follows.

IV. COASTAL HABITAT DIVERSITY

A. Mangroves

Indian mangrove vegetation covers about 6,749 km^2. The entire mangrove habitats are situated in three zones: (1) East Coast, about 4700km^2, (2) West Coast, about 850 km^2, and (3) Andaman and Nicobar Islands about 1190 km^2 with Lakshadweep atoll. These zones have been further categorized into Deltaic, Coastal, and Island habitats. It is estimated that worldwide 48 to 90 species of mangroves exist, India with rich mangrove species diversity inhabits 82 species of mangroves are present in India [11]. Areas under mangrove vegetation (sq.km) mapped in different scales using satellite data (Table 1) shows that West Bengal has highest mangrove cover of 1838.4 sq.km followed by Gujarat 1012.9 sq.km.

TABLE: 1

DISTRIBUTION OF COASTAL HABITATS AT VARIOUS SCALES (VALUES IN SQ.KM^2)

State	Mangroves	Mudflats (non-vegetation)	Mudflats (vegetation)	Saltmarsh
Gujarat	1012.9	20819	4353	1003.875
Maharashtra	147.7	286	254	57.87
Goa	7.0	63	6	0.13
Karnataka	8.5	42	-	32.875
Kerala	10.9	176	25	-
Tamil Nadu	20.2	286	184	255.4416
Andhra Pradesh	380.5	1062	108	259.0525
West Bengal	1838.4	316	-	34.1255
Orissa	187.6	289	143	52.14
A & N	750.8	-	-	-
D,D,D &NH	-----	----------	----------	0.87
Total	**4364.5**	**22339**	**5073**	**1696.3796**

Source: SAC, 1992, 1998

B. Coral Reefs

In the Central Indian Ocean Region, the major reef formations are present in the Indian sub-continent and the Maldives. India has mainly fringing reefs on its mainland coast of Gulf of Kachchh and Andaman and Nicobar Islands. Atolls make up the coral reefs of Lakshadweep. Platform and patch types of reefs dominate the Gulf of Mannar region. Maldives has mainly faros atolls. In India, Coral reefs occur in four major regions; Gulf of Kachchh and Lakshadweep in Arabian Sea, Gulf of Mannar, Andaman and Nicobar Islands in Bay of Bengal. One off-shore reef is found in Malvan, Maharashtra.

The comparison of coral reefs for over two decades (Table 2) shows that there is decrease in coral cover in Gulf of Kachchh and Gulf of Mannar region especially because of tsunami and increasing

turbidity [12]. National Biodiversity Authority recorded total 208 species of corals in India it includes 36 species from Gulf of Kachchh, 91 from Lakshadweep, 82 from Palk Bay and Gulf of Mannar and 177 from Andaman and Nicobar Islands.

TABLE: 2 COMPARISON OF CORAL REEF AREA OF INDIA OVER TWO DECADES (SQ.KM)

Sr. No	Reef Region	1987-90	2004-07	Difference
1	Gulf of Kachchh	460.20	352.50	-107.70
2	Malvan	-	00.28	00.28
3	Lakshadweep	816.10	933.70	117.60
4	Gulf of Mannar	94.30	75.93	-18.37
5	Andanman and Nicobar Islands	959.30	1021.463	62.163
	Total	**2329.90**	**2383.873**	**53.973**

(Source: SAC, Ahmadabad (ISRO) "Coral Reef Atlas of the World" Vol. 1 2010

C. Coastal Sand Dunes

The coastal sand dunes ecosystem is generally neglected by the scientific community. The coastal sand dunes along the entire Indian coast are very poorly documented. Few studies give approximate distribution of coastal dunes in few areas, for example, some of the oldest and best established dunes of Tamil Nadu lie close to the south Poigainnallur region in Nagapattinam district. Some studies reported vast stretches of sand dunes along almost all the coastal districts in Tamil Nadu [13]. It is recorded that the coastal dunes stretch over 9 sq.km occupy a position higher to beaches, while at places it merges with beach sand.

The dune occurs along the coast as transverse dune and occupies a wide zone especially west at Madgaon in Goa [14]. A key component that guarantees stability of coastal sand dunes (CSDs) is vegetation. A study on floristic composition and distribution from CSDs of India revealed a total 338 species of CSD flora, of which 92 species are found to be common to the west and east coasts. The west coast showed a greater diversity than the east coast, accounting for 267 and 163 species respectively. Coastal sand dunes are the important sites for a variety of flora, fauna and microbes. Coastal sand dune plant species have value-added nutritional, medicinal and agricultural uses [15].

D. Mudflats/Biologically Active Mudflats

The Indian coastline has extensive mud flats covering an area of more than 38,000 km^2. Most of the larger river mouths are concentrated in the north-east and northwest coastal areas and hence the muddy coasts of India are mainly located in these areas. India's non-vegetated mud flats have a total area of about 22300 km^2, 90% of which are located in the state of Gujarat in the north-west of the country [16]. The vegetated category is also in large part situated in this area i.e. 4353 km^2 out of a total of about 5073 km^2 as shown in Table 1.

E. Marine Protected Areas

There are a total of 31 Marine Protected Areas in India, covering a total area of 6271.2 km^2 with an average size of 202.1 km^2. East coast and Andaman and Nicobar Islands have adequate areas in the MPAs, whereas west coast and Lakshadweep islands have poor representation [17]. The 31 MPAs cover an area of 18.5 percent of the islands and 6.16 percent of the coastal bio-geographic zones. It is

proposed to increase this area to 36.14 per cent and 7.12 per cent, respectively. Currently, 31 MPAs cover an area of 4 percent of the total area under protection.

F. Salt Marshes

Salt affected soils occupy about 7% of the worlds land area and a large number of halophytes and mangrove species grow luxuriantly in salt marshes. These plants are useful in increasing forage, fuel and food production of saline wetlands. Although many salt tolerant species occupy a long sea coast of India, little information is available on spread of salt marshes and its communities across states. According to a wetland survey conducted by the Space Application Center [18] a total of 1696.3796 sq. km area under salt marshes in India as shown in Table 1.

G. Turtle Nesting Grounds

Although sea turtles live most of their lives in the ocean, adult females must return to beaches on land to lay their eggs. They often migrate long distances between foraging grounds and nesting beaches. There are seven species of marine turtles namely flatback, green sea turtle, Hawksbill, Kemp's Ridley, Leatherback, Loggerhead and Olive Ridley. South Asian waters including India has major nesting ground beaches for five endangered species of marine turtles namely green sea turtle, Hawksbill, Leatherback, Loggerhead and Olive Ridley.

All the aforementioned marine turtle's species are listed under the category of Endangered Species Act (ESA). Only the Green turtles and Olive Ridley turtles have more than one ESA status as they have a breeding population and are listed separately under the ESA. Indian government is also taking strict actions to protect these five endangered species of marine turtles found in India under the Indian Wildlife Protection Act (1972), and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITIES).

While turtles nest both on the east and west coasts of India mass nesting has been observed at three sites in Orissa as shown in Table 3. The three main rookeries or turtle nesting beaches along the 480 km stretch of the Orissa coast are the Gahirimatha between the Brahmini and Baitarani, located north of Paradip; the rookery at the Devi river mouth, about 100 km south of Gahirimatha; and the rookery located 320 km south of Gahirimatha, near the mouth of Rushikuliya river.

TABLE 3: NESTING SITES FOR SEA TURTLES IN INDIA

Location	Species Recorded	Confirmed Nesting	Known nesting beaches
West Coast	Green, Olive ridley and Leatherback	Olive ridley and green sea turtle	**Gujarat:**Mandavi in Kachchh, Sea beach between Okay and OkhaMadhi, Bhaidar, Beyt, Nora and Chank Islands. **Maharashtra:**Gorai, Khim, Manowrie and Versova
East Coast	Olive ridley, Green Hawskbill, Leatherback and Loggerhead	**Olive ridley**	**Tamil Nadu:** Nest in Gulf of Mannar, Point Calimere, and 50 km coastline south of Madras. **Andhra Pradesh:** Kakinada coast, sea beach near the mouth of Godavari and Krishna and near Visakhapattanam **Orissa:** All along the coast south of Dhamra river mouth. Two mass nesting beaches at Gahirimatha and Rushikulya **West Bengal:** In thesandy beaches of Sunderbans
Islands (A&N) and Lakshadweep	Olive ridley, Green, Leatherback, Hawksbill and Loggerhead	Olive ridley, Green, Hawksbill and Leatherback	Great Nicobar, Little Andaman, Rutland, Middle Andaman, Katchal, South Sentinel, South Reef and Teris Islands

(Sources: Please refer Text)

H. Horseshoe Crabs

Horseshoe crabs habitat consists of temperate and tropical seas. The coast of Orissa, especially the wetland areas provide favorable living conditions and breeding grounds for Horseshoe Crabs. Two species of Horseshoe Crabs *Carcinoscorpius Rotundicaeuda* and *Tachypleusgigas* are found along the east coast of India. It was observed that due to habitat changes and anthropogenic changes population of these species is declining and spread is confined only to specific pockets like Eakakula beach, Balarampur and Chandipur beaches of Balasore district and Hukitola areas of Kendrapada district of Orissa.

I. The Seagrass Beds

In India, Seagrass habitats are largely ignored from the educational, research and management points of view. The major Seagrass meadows in India occur along the southeast coast (Gulf of Mannar and Palk Bay) and in the lagoons of islands from Lakshadweep (Arabian Sea) and Andaman and Nicobar (Bay of Bengal). The flora comprises 15 species and is dominated by *Cymodocea Rotundata, C.serrulata, Thalassiahemprichii, Haloduleuninervis, H.pinifolia, Halophilabeccarii. Greatest species rich*ness and biomass of Seagrass occur mainly in open marine sandy habitats.

Associated and epiphytic floras mainly consist of marine algae and are dominated by members of the rhodophyceae group. Various fishes, mollusks, crustaceans, and echinoderms form the predominant associated fauna. Macrofauna mainly comprised of Oligochaetes (40.17%) Polychaetes (18.96%), Crustaceans (11.36%) and Nematodes (18.71%) while meiofauna groups mainly consisted of Turbellaria (34.17%), Nematoda (37.3%), and Harpactcoida (10.11%) [19].

J. Birds Nesting Grounds

Over 1,200 bird species across the world are currently under threat of extinction, which is about 12% of the world's bird species. In India 78 bird species are globally threatened, and to address this, the Indian Important Bird Areas Programme (IBA) was launched by the Bombay Natural History Society (BNHS) in 1999. One of the major aims is to identify and protect IBAs through out the country using a set of standard criteria.

As part of this program BNHS has recommended Bhusandpur and Tinimuthan areas of about 60 sq.km be declared as a new bird sanctuary in addition to the existing sanctuary at Nalaban island. Burnt island (Bandra) Vengurla Rocks, Mahul-Sewree Creek and Thane Creek is identified as Important Bird Areas in Maharashtra which are famous for large congregation of waders and flamingos [20]. Point Calimere Wildlife Sanctuary and the adjoining great Vedaranyam swamp are an important wintering and staging area for over 1000,000 waders and other water birds. The swamp is of great importance as a

staging area for migrants on their way to and from Sri Lanka and other wintering grounds.

Chilika Lake is the world's second largest brackish-water lagoon which attracts over 300,000 birds from December to May. A total of 37 species of shorebirds and seven other important species were identified in Bhitarkanika and Chilika wetland. About 50,000 water birds were recorded from Gulf of Mannar Biosphere Reserve in TamilNadu. Pulikat Bird Sanctuary on the south coast of Andhra Pradesh is second largest brackish water lagoon in India after Chilika. Over 200,000 waterbirds were recorded in 1988 and 1989, including, over 30,000 greater flamingos [21].

The state of Gujarat support large number of birds especially at Ghee Dam, Jamnagar, Shian Dam 65,000, 39,080 and 10,000 Demoiselle Cranes and 3,500 common cranes were recorded respectively. Besides this 200 Black necked Grebes' with additional observations of water birds were recorded from Charkala Salt farm, Jamnagar and Porbandar coastal town [22].

K. Structures of Archaeological Importance and Heritage Sites

As per the Coastal Regulation Zone (CRZ) Notification of the 19th February 1991 and 6th January 2011 all areas of outstanding natural beauty/historical heritage areas are classified as CRZ I. No construction activities are permitted in this area. The list of heritage sites specifically classified as CRZ I as shown in Table 5. Urgent action should be taken to list all heritage sites falling within the Coastal Regulation Zone and getting them classified as CRZ I by the National Coastal Zone Management Authority/State Coastal Zone Management Authorities. This will give immediate protection to a large number of heritage sites which enjoy immediate protection to a large number of heritage sites which does not fall under any form of protection [23].

Table 4: National Heritage Sites declared as CRZ –I as per CRZ Notification 1999

Goa	Andhra Pradesh	Tamil Nadu
1. Tiracol Fort 2. Chapora Fort, 3. Dona Paula	1. Bhimanipatnam	1. Mamallapuram 2. Poomphukar 3. Nagore 4. Rameshwaram, 5. Thiruchendur, 6. Kanyakumari
Maharashtra	**Daman**	**Diu**
1. All island forts, 2. Elephanta island	1. Moti Daman Fort 2. Nani Daman Fort	1. Mamallapuram 2. Poomphukar 3. Nagore 4. Rameshwaram, 5. Thiruchendur, 6. Kanyakumari
Kerala		
1. Puvar South 2. Pulinkudi-Kovalam 3. Sankumugham 4. Veli 5. Papansam-Varkala 6. Edava 7. Kappil 8. Poshikkara 9. Mondakka 10. Thirumullavaram	11. Palliyamturth 12. Alapuzha 13. Fort Kochi Cherai 14. Bekal 15. Kottikulam 16. Vettukar 17. Papanasam 18. Pozikkara-Paravur 19. Neendakara 20. Arthungal	21. Kottukal 22. Angengo Fort 23. Thangasseri 24. Karunagapally 25. Ambalapuzha 26. Vaikam 27. Mattancherry 28. Chennamangalam 29. Parur 30. Chemanchery-Quilandy 31. Bekal

(Source: INTACH & Archeological Survey of India 2002)

L. The Area between Low Tide Line and High Tide Line

Under the CRZ Notification of the 19th February 1991 and 6th January 2011 restrictions have been imposed on development and construction within 500 meters of the High Tide Line in the case of the sea, and lesser distances in the case of rivers, creeks and backwaters which are subject to tidal action.

IV. THREATS TO BIODIVERSITY AND HABITAT QUALITY

Surrounded by the Indian Ocean, Arabian Sea and the Bay of Bengal, Indian coastline spans 13 maritime mainland States and Union Territories (UTs). India is home to a variety of coastal and marine ecosystems that are storehouses for biodiversity. About 47 percent of the population lives in the coastal states. 60 per cent of the labor force is occupied in agriculture.

The Gross Domestic Product (GDP) contribution by sector is agriculture 25 per cent, industry 26 per cent and services 49 per cent. Human settlements with large populations and numerous small and medium-scale industries, large industries, as well as power plants are situated along the coast. The combination of discharges of raw sewage and untreated industrial waste has caused serious degradation of coastal environments. Some of the largest and most dense urban agglomerations are Mumbai, Kolkata, Chennai and Visakhapatnam. Since coastal population survives mainly on marine resources, overexploitation of essential resources has threatened the ecosystem [24], [25], [26].

Global Biodiversity Outlook [27] recognized five main threats to biodiversity worldwide. These threats include habitat loss/change, coastal pollution and nutrient load, overexploitation, climate change and invasive alien species. Unless we successfully mitigate the impacts of these direct drivers of change on biodiversity, they will contribute to the loss of biodiversity components, negatively affect ecosystem integrity and hamper aspirations towards sustainable use.

Beside these direct drivers of biodiversity loss, there are a number of indirect drivers that interact in complex ways to cause human-induced changes in biodiversity. They include demographic, economic, socio-political, cultural, religious, scientific and technological factors, which influence human activities that directly impact on biodiversity.

Habitat destruction is particularly pervasive in tropical areas [28] where mangroves, coral reefs and wetland areas are being destroyed at alarming rates. In India, the major stresses on marine and coastal ecosystems are storms and waves, particularly cyclones. High speed winds ranging from 65 to 120 km per hour cause extreme wave action that kills many flora and fauna [29].

A. Habitat Loss/Change

Coastal habitats, especially wetlands, coral reefs, mangroves, salt marshes, and sea grasses, are rapidly being cleared for urban, industrial, and recreational growth as well as for aquaculture ponds. The estimates of coastal habitat loss are not available. Wetlands are responsible for maintaining reproductive fisheries not only by way of catch but as feeding, spawning and nursery grounds as well. About 90 per cent of the world's marine fish catch (measured by weight) is produced in these wetland these areas.

Thus, degradation of coastal habitats can have long-term consequences for fish populations. Apart from this, they also serve as buffer for the mainland against ocean storms and protect the coast from erosion. The knowledge about extent, condition and destructive uses of wetlands is vital for coastal management programs [30].

Habitat conversion and degradation are generally thought to be the most significant threats to terrestrial life. Within marine ecosystems, they rank along with overexploitation and pollution as major causes of biodiversity loss. Coastal development contributes to habitat loss in a number of ways. These include conversion of mangroves and other wetlands as a result of urbanization and agricultural expansion, the building of shoreline stabilization structures such as breakwaters, mining, oil drilling, dredging and filling [31].

B. Coastal Pollution

The country is characterized by high population density; low income, low development indicators, and high dependence upon natural resources for livelihood characterize the country. Additionally, diverse forms of political instability stemming from religious, ethnic, and language differences, as well as resources scarcities contribute towards the low level of socio-economic development of the majority of the people.

Dealing adequately with the sources of land-based marine pollution requires parallel attention to the causes of poverty, particularly in relation to sanitation, cultivation practices, land use and sustainable use of coastal and marine resources [32]. Population growth, urbanization and industrialization are major causes of coastal pollution. Coastal pollution in India arises mainly from land based sources such as domestic waste, industrial effluents, and agricultural runoff. Other sources include shipping activity, offshore exploration, infrastructure development and the crop of recently started coastal industries which uses sea-water as a resource and the coastal domain as a sink of altered sea-water. Major pollutants in coastal and marine environments include oil and sewage, garbage, pesticides, toxic chemicals, heavy metals, radioactive waste, thermal pollution and nutrients [33].

Fertilizers, sugar, textiles, chemical, mines and minerals, pulp and paper and tanneries are major industries causing coastal pollution. An input of pollutants in coastal environment is represented in Table 5. Six priority issues have emerged from regional workshops and national studies for the South Asian Sea (SAS) region viz., sewage, litter-solid waste (industrial and municipal) agricultural chemicals; oil hydrocarbons; sediment; and physical alteration and destruction of habitats [32].

Among them four issues have emerged as requiring priority, namely sewage and management of municipal wastewater, nutrient over-enrichment, marine litter and physical alteration and habitat destruction [35]. Some of these substances are biodegradable while others are persistent. Their cumulative effect over a long period could be quite harmful to the coastal marine environment. These effects are, as yet, not very perceptible over the entire Indian coast. But near a few big cities and industrial conglomerates the effects are indeed, becoming near disastrous [35].

TABLE 5: ANNUAL QUANTUM OF POLLUTION LOAD IN INDIAN COASTAL AREAS TILL 2008

Sr. No.	Input / pollutant	Quantum - Annual
1.	Sediments	1600 million tonnes
2.	Industrial effluents	50×10^6 m^3
3.	Sewage - largely untreated	0.41×10^9 m^3
4.	Garbage and other solids	34×10^6 tonnes
5.	Fertilizer - residue	5×10^6 tonnes
6.	Synthetic detergents - residue	1,30,000 tonnes
7.	Pesticides - residue	65, 000 tonnes
8.	Petroleum hydrocarbons (Tar balls residue)	3,500 tonnes
9	Mining rejects, dredged spoils & sand extractions	0.2×10^8 tonnes

(Source: NIO, 2008)

Some observations [36] demonstrated high concentration of nutrients, low dissolved oxygen, and biochemical and chemical oxygen demand in coastal surface waters near cities. The trace/toxic metal concentrations are found to be significantly higher than the permissible limit of international standards. Some major environmental hotspots include Mumbai, Kolkata, Chennai, Ankleshwar (Gujarat), Kochi and Goa are the places where human health and the environment are significantly impacted by pollution. However, it is concluded that the toxic metal concentrations are within the permissible limits for human consumption and overall Indian coastal waters are still in good condition [35], [32].

Economic growth and development, which are accelerating with increasing human population, urbanization, and industrialization in the region have led to increased pressures on the region's costal and marine environments. In this context, strong institutional mechanisms and good governance principles need to guide the behavior of both political leaderships and the vast population in the region that contributes to the existing problems. In the absence of this there are likely consequences of deterioration in all relevant environmental and social indicators [31].

C. Climate Change

Tropical Asia is physio-graphically diverse and ecologically rich in natural and crop-related biodiversity. The present total population of the region is about 1.6 billion, and it is projected to increase to 2.4 billion by 2025. The population is principally rural-based, although in 1995, the region included six of the 25 largest cities in the world. The climate in Tropical Asia is characterized by seasonal weather patterns associated with the monsoons and the occurrence of tropical cyclones.

Climate change will add to other stresses such as rapid urbanization, industrialization and economic development, which contribute to unsustainable exploitation of natural resources, increased pollution,

land degradation and other environmental problems. Sea-level rise and increases in sea-surface temperature are the most probable major climate change-related stresses on coastal ecosystems. Coral reefs may be able to keep up with the rate of sea-level rise but suffer bleaching from higher temperatures. Landward migration of mangroves and tidal wetlands is expected to be constrained by human infrastructure and human activities [36].

Coastal lands are particularly vulnerable; sealevel rise is the most obvious climate-related impact. Densely settled and intensively used low-lying coastal plains, islands and deltas are especially vulnerable to coastal erosion and land loss, inundation and sea flooding, upstream movement of the saline/freshwater front and seawater intrusion into freshwater ward. Socio-economic impacts could be felt in major cities and ports, tourist resorts, artificial and commercial fishing, coastal agriculture and infrastructure development. International studies have projected the displacement of several millions of people from the region'scoastal zone, assuming a 1-m rise in sea level. The costs of response measures to reduce the impact of sea-level rise in the region could be immense [37].

The incidence and extent of some vector-borne diseases are also expected to increase with global warming. Adaptive options include improvements in irrigation efficiency and integrated approaches to river basin and coastal zone management that take account ofcurrent and longer-term issues, including climate change.

D. Overexploitation

Continued exploitation of species is leading to changes in species composition, loss of biodiversity, and shifts in dominance and survivability. Much of the global fishing effort is targeted at a few species, located primarily near the top of the food chain. Poor management practices, subsidization of the fishing industry, uncontrolled harvests within international waters, and destructive and wasteful capture methods are to blame for the over exploitation of most marine species [31].

India's extensive coastline is rich in diverse living resources. These resources continue to deteriorate with rampant harvesting or are altered for other uses such as aquaculture and fisheries. The impacts of biodiversity loss and their after-effects on the ecobalance of this coastal system have become a matter of great concern to ecologists to maintain security and sustainability. A public awareness program on themes relating to the importance of biodiversity for human livelihoods is proposed [38].

E. Invasive Alien Species

Invasive species are a growing problem for the world, both ecologically and economically. The impact of invasive species on native species and ecosystems has been immense. Invasion is considered to be an important driver of global change. The impact on economy by these species is

evident. The cost of impact which invasive species cause is now estimated to range from millions to billions of dollars and eventually it would be severe for all ecosystems.

About 18% of the Indian flora constitutes adventive aliens, of which 55% is American, 10% Asian, 20% Asian and Malaysian, and 15% European and 10% Central Asian species. Although large number of exotics have become naturalized in India and have affected the distribution of native flora to some extent, only a few have conspicuously altered the vegetation patterns of the country. The *Cytisus scoparius, Chromolaen aodorata, Eupatorium adenophorum, Lantana camara, Mikania micrantha, Mimosa invisa, Parthenium hysterophorus and Prosopis juliflora* among terrestrial exotics, and *Eichhornia crassipes* and *Pistia stratiotes* among aquatics, have posed serious threat to the native flora [40].

However no records are available for the invasiveness of species in coastal waters of India. The ecosystem level consequences of invasion are, still little understood and there is an urgent need of studies on biological invasions in India.

VI. CONSERVATION NEEDS

The gaps and deficiencies revealed in most of the studies [36], [41], [28], [42], [18] suggests some priority areas such as better baseline data, both climatic and socio-economic for further work to help policy makers in their difficult task. Some of the recommendations for better management of coastal habitats in India are as follows

- To follow up and implement strictly the Costal Regulation Zone (2011) taking public into confidence through widespread education and awareness.
- Integrating physical and socio-economic approaches will represent a conceptually correct means of addressing the unifying issues of economic and environmental sustainability rather than giving stress on physical parameters of environment only.
- Probably the most important aspect of the marine pollution in Indian Ocean region is to examine the physical processes in the recipient water body. Outfalls from large cities or industrial belts and from free trade zones in the form of industrial waste and domestic sewage opening into coastal and nearshore waters need to be examined.
- Baseline data of many dangerous pollutants particularly pesticides, herbicides and insecticides in the coastal marine environment of this region is lacking. Efforts should be made to collect maximum possible data from the sources and sinks on as many pollutants as possible.
- If marine biodiversity is conserved better protection of the coasts outside marine protected

areas is needed. Habitats themselves occur as a mosaic of interconnected units thus the mosaic of habitats, the landscape, must be considered.

- ❖ Priorities of people in developing countries like India focus more on food production rather than conservation of biodiversity, in this case natural scientists, users of the habitats, managers, planners, economists and policy makers must be included in conservation.
- ❖ Scenarios for precipitation, extreme events, sulfate aerosol effects and regional-scale changes needed.
- ❖ Better understanding of the ecological and physiological effects of increasing CO_2 concentrations is essential
- ❖ Dynamic models of climate, biospheric processes and other socio-economic factors to take account of the developing, time-varying nature of global change.
- ❖ Analysis of adaptation options, including the need for development of new technologies and opportunities for adapting existing technologies in new settings.
- ❖ Integrated assessments across sectors, from climate change to economic or other costs, across countries and regions, including adaptations, and including other socio-economic changes.

V. CONCLUSION

Even though many studies in coastal areas of India are carried out by number of institutions and individuals about biodiversity, coastal habitats and threats these are site and issue specific, studies at the national level are very few. Fragmented information about various issues and information gap suggests that assessing coastal habitats for its management is a difficult task. All though some habitats are considered as Ecologically Sensitive Areas (ESA) as per the CRZ 2011, it is difficult to identify, and map these habitats due to lack of sufficient data or information at the national level. Present article highlighted the current status, potential threats and possible remedial measures which can bring to common platform for implementing the action agenda towards the integrated management of coastal habitats in India.

ACKNOWLEDGEMENT

Authors are thankful to the Director and staff of SICOM for the support. Authors are also thankful to MoEF for financial support through World Bank ICZM Project.

REFERENCES

[1] Barton, T., Borrini-Feyerabend, G., de Sherbinin, A. and P. Warren "Our People, Our Resources", IUCN, Gland, Switzerland and Cambridge, UK., 1997

[2] Sorensen, J. "The international proliferation of integrated coastal zone management efforts", Ocean and Coastal Management, 21, 1-3 PP45-80, 1993

[3] UNEP /GPA. "The State of the Marine Environment: Trends and Processes" UNEP /GPA, The Hague, 2006

[4] Ahmad E. "Coastal Geomorphology of India" Orient Longman Part III Coastal Features PP161-195, 1972

[5] Singh, S.K,, "Spatial Variability in erosion in the Brahmaputra basin: causes and impacts" Current Science, v. 90, p. 1272-1276, 2006

[6] Nayak G.N. "Indian Ocean Coast, Coastal Geomorphology" In Schwartz M.L (ed.) Encyclopedia of Coastal Science, PP 554-556, 2005

[7] Wafar M., Wafar S., Yennawar "Indian Ocean Islands, Coastal Ecology and Geomorphology; In Schwartz, M.L. (ed), Encyclopedia of Coastal Sciences, Springer, PP557-564

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

[9] Ingole B., "Indian Ocean Coasts, Coastal Ecology" In Schwartz, M.L. (ed), Encyclopedia of Coastal Sciences, Springer, PP 546-554, 2005

[10] Mandal R.N., Naskar K.R. "Diversity and classification of Indian Mangroves: a review" Tropical Ecology 49 (20: 131-146, 2008; International Society for Tropical Ecology

[11] SAC, Coastal Environment, Scientific Note, Space Application Center, Ahmedabad, India, 1992

[12] Namboothri, N., D. Subramanian, A. Sridhar, S. Rodriguez, M. Menon, and K. Shanker, *Policy Brief: Sand Dunes*. UNDP/UNTRS, Chennai and ATREE, Bangalore, India, 12 p. 2008

[13] Choudhary S.B., Rao K.H.,Rao M.V. "Sattelite remote sensing for marine resources assessment" Tropical Ecology 43(1): 187—201, 2002; International Society for Tropical Ecology

[14] Rodrigues R.S., Mascarhenas A and Jagtap G, "An evaluation of flora from coastal sand dunes of India: Rationale for conservation and management Ocean & Coastal Management, vol.54 (2); 181-188, 2011

[15] Sridhar K R and Bhagya B 2007**:** Coastal sand dune vegetation: a potential source of food, fodder and pharmaceuticals. *Livestock Research for Rural Development. Volume 19, Article #84.* Retrieved September 1, 2011from http://www.lrrd.org/lrrd19/6/srid19084.

[16] Baba M, Nayak S.R. "Muddy coasta of India and Sea-level rise" In Muddy Coasts 97 An International Senkenberg Conference on Hydrology, Sedimentology, Geochemistry, and Ecology of Muddy Coasts1-5 September, Wilhemshavan, Germany, 1997

[17] Singh H.S. "Marine Protected Areas in India" Indian Journal of Marine Sciences, Vol, 32 (3), PP 226-233; September, 2003

[18] Nayak, S. "Monitoring the coastal environment of India using Satellite data". Science, Technology & Development, 14 (2): pp. 100-120. 1996

[19]Jagtap T.G, Komarpant D.S. and Rodrigues R. S "Status of Seagrass Ecosystem: An ecological sensitive wetland habitat from India" Wetlands Vol. 23, No.1, PP- 161-170, March, 2002; The Society of Wetland Scientists

[20] Nayak, S. and Bahuguna, A. "Application of Remote Sensing Data to Monitor Mangroves and Other Coastal Vegetation of India; Indian" Journal of Marine Sciences; 30(4): 195-213, 2001.

[21] Bhalchandra " The decline in wader populations along the east coast of India with special reference to Point Calimere, Southeast India *Waterbirds around the world* Ed G.C. Boere, C.A. Galbraith and D.A Straud The Stationary Office, Edinburg, U.K., P-296-301

[22] Mukherjee A and Wilske B, "Important Bird areas in western India", *Waterbirds across the world* Ed G.C. Boere, C.A. Galbraith and D.A Straud The Stationary Office, Edinburg, U.K., P-302, 2006

[23] Chainani S. "Heritage Policy for India" *In a case for national policy for heritage conservation and management* Proceeds of workshop on National Policy for Heritage Conservation and Management held on 14th-15th February, 2002, New Delhi PP 25-36 INTACH and A.S.I.

[24] UNEP "A Comparative Review of Coastal Legislation in South Asia" GPA Coordination Office, The Netherlands and International Ocean Institute, India, Chapter 5 pp 77-107; May 2003

[25] Mani J.S. "Report: Coastal Zone Management Plans and Policies in India" Coastal Management, Taylor and Francis; 25:PP 93-108, 1997

[26] UNEP/GPA "The State of the Marine Environment; Regional Assessments", Chapter 6 PP 137-156, UNEP/GPA, The Hague, July 2006

[27] Secretariat of the Convention on Biological Diversity *Global Biodiversity Outlook 2*. Montreal, 81 + vii pages, 2006

[28] Gray John S., "Marine Biodiversity: Patterns, Threats and Conservation needs" Biodiversity and Conservation 6 PP 153-175; 1997

[29] Venkataraman K and Wafar M, "Coastal and Marine biodiversity of India" Vol, 34 (1) PP 57-75, March 2005

[30] Nayak S. "Use of satellite data in coastal mapping" Indian Cartographer, 2002 PP-147-155 From: http://www.incaindia.org/technicalpapers/24_CMMC01.pdf

[31] Trivikramaji K.P. and Rajan A.N. "Pressures on Marine Biodiversity" EMCB-ENVIS Node on "Marine Ecosystem" Department of Geology, University of Kerala, Vol. 2, No. 4; December 2003

[32] UNEP/GPA "The State of the Marine Environment; Trends and Processes" UNEP/GPA, The Hague, 2006

[33] NIO "Coastal and Marine Pollution" National Institute of Oceanography, Goa, March 2008 retrieved from: http://saarc-sdmc.nic.in/pdf/workshops/goa/india/COASTAL%20AND%20MARINE%20POLLUTION.pdf

[34] UNEP "South Asian Seas" 2005 retrieved from the website www.gpa.unep.org/seas/workshops/sasian.ht.

[35] Sengupta R, Naik S, and Varadchari V.R. "Environmental Pollution in Coastal Areas of India" Ecotoxicology and Climate Ed. Bourdeau, J.A, W Kleain and C.R. Krishna Murti; SCOPE, Published by John Wiley & Sons Ltd. PP 235-246; 1989

[36] Shanmugam P, Neelmani S, Ahn Y, Phillip L, Hong GI-Hoon " Assessment of the levels of coastal marine pollution of Chennai City, Southern India; Water Resource Management: Springer; 2006

[37] IPCC; "Summary for Policy Makers The Regional Impacts of Climate Change: An Assessment of Vulnerability" Eds. Watson R.T., Zinyowera M.C., Moss R.H., Dokken D.J., A special report of IPCC working group II; November 1997

[38] Bhattacharya B. Sarkar S.K., Mukherjee N,. " Organochlorine Pesticide

residues in sediments of tropivcal mangrove estuary, India; implications for monitoring" Environmental International Vol. 29, Issue 5 PP-587-592; August 2003

[39] UNEP "Environmental Problems of the marine and coastal area of India: National Report; UNEP Regional Seas Reports and Studies No. 59 PP 1-28 UNEP 1985

[40] Salm, R.V. and Clark J.R. (1984) Marine and coastal protected areas: a guide for planners and managers, Gland Switzerland; IUCN

[41] Upadhyay, V.P., Rajiv Ranjan and J.S. Singh, "The Human Mangrove Conflicts- The way out". Current Science. 83: 1328-1336. 2002.

[42] Mascarenhas A, Jayakumar S. An environmental perspective of the post-tsunami scenario along the coast of Tamil Nadu, India: Role of sand dunes and forests. J Environ Manage 2008; 89: 24-34.

[43] Fortes M.D. "Seagrass-mangrove ecosystem management: A key to marine coastal conservation in the ASEAN region; Marine pollution Bulletin; Vol. 23 PP113-116; 1991