

Review

WETLAND ECOSYSTEMS AND COASTAL HABITAT DIVERSITY IN GUJARAT, INDIA

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ABSTRACT

Wetland ecosystems are the major contributors for the nations' wildlife biodiversity, productivity and economy. The paper elaborates the habitat diversity of wetlands in Gujarat, India, the floral and faunal diversity of each ecosystem, the major industrial and development pressures posed by the mangroves and coastal ecosystems. Thus indicates the significance and necessity for wetland habitat conservation.

Key Words: Biodiversity Hotspots, Wetlands, Mangroves, Corals, Pressures.

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INTRODUCTION

Gujarat is located on the Tropic of Cancer (Lat 20⁰01' to 24⁰07'N and Long 68⁰04' to 74⁰04'E); falls in the sub-tropical climatic zone and has a varied climate and climatic regions. Gujarat has the longest coastline of about 1663km in India. The vast continental shelf varies in width from 58 to 191 miles with 64,810 sq.km of area having depths of less than 50m and another 99,373sq.km with depth 50 to 200m. Therefore Gujarat's fishing ground is extensive.

The various seasons of the year are monsoon (June-October), winter (November-February) and summer (March to June). The temperature varies between 8⁰ to 45⁰C. It receives rainfall from the southwest monsoon and with the

maximum during the months of July and August. Relative humidity is low in all parts of the state. Intensity of wind is more during late summer and monsoon.

The hydrological regime of the state is governed by the complex geo climatic condition. Most of the ground water resource is concentrated in the unconsolidated formation, covering about 40 of the area of the state. The surface water is dominantly concentrated in the southern and central parts of the state.

The Banas, Sabarmati, Mahi, Narmada and Tapi are major rivers draining into the gulf of Khambhat while the rivers Bhader, Ojat and Shetrunji are those of Kathiawar peninsula draining into the Arabian Sea. There are few seasonal small rivers draining into the gulf of Kachchh (**Table 1**).

Table 1. Status of the major Rivers in Gujarat

Region	Name of the river	Length flowing in Gujarat (Km)	Catchment area in Gujarat (sq.km)	Average annual runoff (MCM) (Avg. of 1982-1993)	Nature of River
North Gujarat					
	Sabarmati	323	18495	870.52	Ephemeral
	Banas	188	5405	42.86	Ephemeral
	Saraswati	-	2282	18.62	Ephemeral
	Rupen	156	2662	143.71	Ephemeral
	Rel	-	238	9.82	Ephemeral
South and Central Gujarat					
	Narmada	159	11399	6016.31	Perennial
	Tapi	214	3837	6627.67	Perennial
	Mahi	242	11694	4807.18	Perennial
	Dhadar	142	4201	511.90	Ephemeral
	Kim	107	1330	311.16	Ephemeral
	Purna	142	2431	1466.92	Ephemeral
	Ambica	136	2715	1307.86	Ephemeral
	Damanganga	33	495	2938.94	Ephemeral
Saurashtra Peninsula					
	Shetrunji	182	5571	34.72	Ephemeral
	Bhader	198	7075	353.33	Ephemeral
	Machhu	141	2515	-	Ephemeral
	Saraswati	-	-	70.96	Ephemeral
Kachchh Peninsula					
	Khari	-	373	-	Ephemeral
	Pur	-	-	0.27	Ephemeral
	Kanakavati	-	275	0.81	Ephemeral
	Gjansar	-	-	0.28	Ephemeral

Source: ORG (1999), CWC (1997) and planning Atlas of Gujarat

SALIENT BIODIVERSITY HOTSPOTS OF GUJARAT

Gujarat is bestowed with one of the most diverse kinds of wetlands in the country including mangroves, coral reefs, beaches, mudflats, tidal flats, flood plain systems and fresh water lakes and reservoirs.

The unique bio diversity hotspots of Gujarat are as follows:

- Flamingo city between Khadir and pahchhm belts in Gujarat in Great Rann of Kachchh – breeding ground of migratory flamingoes.
- Northern arid regions of Kachchh – habitat for the Spiny tailed lizard, *Uromastix hardwickii*.
- Wild Ass Sanctuary of Little Rann of Kachchh – home for the last surviving population of Indian Wild Ass.

- Gaga Great Indian Bustard Sanctuary – Grassland supporting the majestic bird, the Great Indian Bustard listed in the Red Data Book.
- Vansda National Park, Valsad District
- Vajpur Forests of Surat District
- Vijayanagar Forests of Sabarkantha District
- Velvadar National Park
- Girnar Forests of Junagadh District
- Narayan Sarovar Chinkara Sanctuary
- Ratnamahal Sloth Bear Sanctuary
- Nal Sarovar Bird Sanctuary
- Shoolpaneshwar Wildlife Sanctuary, Bharuch District
- Purna Wildlife Sanctuary, Dangs District
- Gir Wildlife Sanctuary and National Park, Jungadh District
- Marine National Park in Gulf of Kachchh.

The population of Gujarat is 48,387,270 according to 2001 census. About 29 tribes consisting of about 15% of the population have a large depository of indigenous knowledge on 1200 plants species including 750 medicinal plants. Gujarat, in its four-bio geographic zones recorded 4320 species of plants and 27028 species of animals. Some endangered mammals of Gujarat are Caracal, Desert Cat, Ratel, Long eared Hedgehog, Common Dolphin and Antelope; birds - Lesser Florican, Great Indian Bustard, Indian Skimmer, Sarus Crane and Dalmatian Pelican; Reptiles - Green Turtle, Banded Gecko, Painted Frog and Spiny Tailed Lizard. The indigenous breeds of cattle and Buffuloes in Gujarat are Gir, Kankrej and Dangi and Surati, Mehsani, Jafrabadi and Murah respectively.

The wetlands of the state are major wintering areas for cranes, pelicans, flamingoes, ducks and shore birds. The

only breeding sites for the greater and lesser flamingos in Asia are confined to the Rann of Kachchh. The state also serves as the home for Indian Wild Ass, which is unique and confined to the narrow zones of Kachchh. The only population of Dugong on the West Coast of India is present in the Gulf of Kachchh region.

Taking catch per hour as the criterion, the dominant fisheries in coastal Gujarat include jew fish (sciaenid) and silver grunt in kachchh, Porbandar and Dwarka, golden wam (eel) in Kambhat and Veeraval, cat fish in Kachchh and Porbandar, elasmobranches in Kachchh and other sciaenids in Dwarka, Kachchh, Porbandar and Khambhat.

WETLAND ECOSYSTEM AND HABITAT DIVERSITY IN KACHCHH

Due to geographical situation and prevailing physio-climatic conditions, following major natural eco-systems and habitats can be delineated:

A. Wetlands of Kachchh

There are many natural seasonal wetlands in Kachchh. In total about 258 wetlands were delineated through satellite imageries. These wetlands cover approximately 21772km² area, which is more than 80% of the entire state (SAC, 1998). Majority of these wetlands, are however, found in the saline flatlands of Ranns and Banni. These wetlands support large number of migratory waterfowls in winter.

1. Ranns of Kachchh

Rann is the largest saline and marshy tracts in the world. The Great Rann of Kachchh (GRK) and the Little Rann of Kachchh

(LRK) with an area of about 16780 km² and 5180 km², respectively, constitute the entire Rann of Kachchh. The Ranns in general characterized by flat topography, annual water inundation pattern, high salinity, barrenness and many 'bets' or Islands. The islands are slightly raised isolated patches of land with less salinity and support some xerophytic vegetation.

1a. Great Rann of Kachchh (GRK)

Salt-impregnated GRK is one of the most remarkable and unique ecosystems of Kachchh and probably one of its own kinds in the world due to its wilderness value. The average altitude is about 15 meter above mean sea level, and thus appears like a tabletop surface, interspersed with small uplands (islands) locally called 'bets'. The GRK owes its origin to a marine transgression in geological time scale and is tectonically an unstable area. Ecologically, it represents one of the largest seasonal saline wetland areas having the water depth ranging from 0.5 to 1.5 meter. However, after October-November, water start drying up and the area turns into a saline desert, where the thick deposit of salt crystals is a common scenario.

Fauna

GRK is a refuge for the Indian Wild Ass (*Equus hemionus khur*), a threatened sub species of Asiatic wild ass. Breeding area for Greater Flamingo, Lesser Flamingo, and Great White Pelican. The species such as Lesser Flamingo, Great White Pelican, Avocet and Caspian tern are recorded to breed only in Gujarat in the country. This area supports >50,000 water birds including Great Crested Grebe, Black stork, Brahminy Duck, Common Pochard, Tuffted Pochard, White Eyed Pochard, Gulls, Terns, Stints and Plovers etc., The mudflat areas near Lodrani are considered as one of the rich wetlands in Kachchh for migratory waterfowls. Sarus crane (*Grus*

antigone antigone) is one of the three cranes (others are Common and Demoiselle cranes) visiting Kachchh.

Small fish *Cyrinodon dispar* is common in the Rann. Kachchh recorded very sporadic nesting of two endangered species of turtle viz. Olive Ridley and Green Turtle.

The mixture of saline flat land and raised bets provide ideal habitat for many other wild animal species including desert fox, desert cat, Indian porcupine, saw scaled viper, krait, cobra and several species of lizards especially the spiny tailed lizard.

The Sindal bet, right in the center of the GRK, is popularly known as '*Flamingo City*', which is around 10 km from the Nir out-post on Kala Dungar. The area is famous for the largest congregation of Greater Flamingoes in the entire subcontinent. The area after the rainfall is converted as a marshy island, where the Greater Flamingoes visits for breeding. In 1945, Dr. Salim Ali estimated a population of half million birds from the site. Small mounds of mud make the nests on the ground and on each mounds the birds lay their eggs.

Due to the presence of geologically diverse rocks, many bets also support rich fossilized fauna, including the skull of dinosaur and wood fossils (Singh 2001). In diversity point of view, the area may not be considered as very rich, but it supports one of the magnificent ecological phenomenon, which need to be preserved. Ironically, there is very limited ecological data available about the area and the magnificent phenomenon of breeding. The area is currently a part of Kachchh Desert Wildlife Sanctuary. Inland wetlands in Kachchh also provide habitat for the endangered marsh crocodile (*Crocodylus palustris*).

Flora

The dominant mangrove vegetation along Jakhau, Koteshwar and Lakhpat is mainly

of *Avicennia marina* var. *acutissima*, which forms almost a pure stand. Earlier reports indicate that *Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza* and *Ceriops tagal* were found associated with *Avicennia marina*. Presently these species have become rare or absent.

Huge formations of *Sesuvium portulacastrum* occur on the marshy fringes of mangroves associated with *Salicornia brachiata*, *Suaeda fruticosa*, *Cressa cretica* and *Aelurops lagopoides*. In the low lying areas *Juncus maritimus* occur in pure patches.

In the areas with low salinity grass species such as *Dichanthium annulatum*, *Sehima nervosum*, *Cenchrus siliaris*, *C. setigerus* and *Panicum antidotale* occur along with *Acacia nilotica* and *Capparis* sp.

1b. Little Rann of Kachchh (LRK)

The Little Rann of Kachchh (LRK) is similar to the GRK as far as physiography, climate, vegetation and overall edaphic condition are concerned. However, they are significantly different in silt deposition pattern. While the Indus River has deposited silt in GRK, the LRK shows strong affinity with the silts brought from other rivers of Gujarat. Due to different inundation pattern (due to rain water draining from the rivers like Rupen and Banas), the level of salt deposition on the soil surface is also comparatively less in LRK.

Fauna

The diverse group of organisms such as phytoplankton (107sp), water birds (97sp), fishes (22sp), amphibians (4sp), reptiles (29sp), and invertebrates (93sp) were reported from LRK.

LRK is world famous for the last remaining population of endemic Wild Ass and to protect this species almost entire LRK is covered under Wild Ass Sanctuary

(WAS). According to last census (Jan. 1999), the total population of Wild Ass is about 2839 (GEER, 1999).

LRK also provide ideal habitat for large number of bird species such as Dalmatian Pelican, White eyed Pochard, Indian Skimmer, Common crane, Great crested grebe, Caspian tern, Houbara bustard, Marbled Teal listed in the vulnerable category, Lesser Flamingo as near threatened as per the IUCN red data list and Spoon bill listed threatened as per Wild life protection Act 1972. A total of 178 species of birds, including 81 terrestrial and 97 aquatic, were recorded from the area. About 80,000 birds were counted from different water bodies of LRK (GEER, 1999).

Indian Flapshell Turtle, included in Schedule I of Indian Wildlife protection act 1972 is found in the area. Marsh crocodile (*Crocodylus palustris*) listed as vulnerable by BCPP is present in LRK.

Surajbari is one of the main fish landing centers. The mixing of tidal waters from the Gulf of Kachchh with the freshwater flow during the monsoon makes the area an important nursery ground for prawns. The major fishing centers are therefore found on the western side of the LRK, where from the Surajbari Creek the tidal water goes in. Prawn fishery (*Kutch prawn-Metapenaeus kutchensis*, an endemic species to Kachchh and *M. affinis*) is predominant in this area mainly during the period between late July to early October. Other fish, which are found in and around the sanctuary area, are *Hilsa illisha*, *Hilsa toil*, mullet, bumia, pomfrets, dara, ghol, palla etc. The total annual landing of the fishery from LRK varies from 2500 to 3000 MT (GEER, 1999).

Flora

Suaeda sp, *Aelurops lagopoides*, *Cressa cretica*, *Cyperus* sp and *Chloris* sp are found commonly on the mudflats. Marsh land vegetation comprise *Scripus littoris*, *S.squarrosus* found in ponds and ditches,

Echinochloa colonum found in fresh water puddles, *Cyperus rotandus*, *C. bulbosus*, *C. difformis* found on low lying saline wetlands. Marselia is abundant in pond ecosystems. Various types of algae were also seen in the ponds and waterlogged areas. The species of *Spirulina* common in these areas form the major food for the lesser flamingoes. The rich diatoms and plankton constitute the food for Greater flamingoes and ducks.

The threatened species (BCPP-CAMP in 1997) such as *Aelurops lagopoides* (EN), *Anthrocnum indicum* (VU), *Suaeda maritima* (EN), *Suaeda nudiflora* (EN), *Urochondra setulosa* (EN) and *Tamarix troupitii* (EN) are found in LRK.

2. Wetlands in Banni-Chhari-Dhand

Banni is the largest grassland in India, situated on the northern border of the Bhuj of Kachchh district. There are many depressions in Banni, known as Dhand, Jhil or talav. Shallow wetlands are developed in low-lying parts of Banni after monsoons. In total 34 such seasonal and permanent wetlands exist in the Banni area including Chhari –Dhand, Khirjog-Dhand, Abdha-Jheel and Luna-Jheel. Chhari –Dhand has the maximum water spread area of 80sq.km and falls under the category of seasonally flooded wetland type.

Fauna

Banni supports >20,000 waterfowls from more than 20sp. Species reported includes Dalmatian Pelican and Indian Skimmer listed vulnerable by IUCN.

Flora

Major vegetation is *Prosopis juliflora*, *Acacia* sp, *Calotropis* sp, *Aelurops lagopoides* and sedge grass *Cyperus* sp.

3. Wetlands of Kachchh Peninsula

In total, 2245 village tanks exist in the region. Though these water bodies are smaller in size, they support considerable number of water birds including migratory species.

Inland wetlands also provide habitat for the endangered marsh crocodile (*Crocodylis palustris*). Twelve (12) water bodies and six (6) rivers in Kachchh peninsula reported the presence of marsh crocodile. Khengar Sagar, Pragsar and Edmund reservoirs were the most critical water bodies from the conservation point of view.

Indian Flap shell Turtle was recorded from Kalagogha reservoir, Vijay sagar reservoir, Gajod reservoir, Mandvi Lake and Tapar village tank.

Water bodies contribute the major inland fishery and the common species are major carps Catla, Rogu and Mrigal.

B. Wetlands of Saurashtra Peninsula

1. Khijadia lakes

Seasonal wetlands of fresh water combined with coastal wetland ecosystem forms a unique area.

Fauna

The total of 94 water bird species were identified including Dalmatian Pelican, White eyed Pochard and Indian Skimmer (Vulnerable as IUCN).

Flora

Seven (7) species of macrophytes were reported from the area. The grass species include *Typha angustata*, *Scirpus* sp, *Cyperus* sp, and *Saccharum spontaneum*. Submerged aquatic species are *Hydrilla verticillata* and *Vallisneria spiralis*.

Prosopis juliflora, *Acacia nilotica*, *Salvadora* spp are the tree species and marsh vegetation like *Aelurops* sp and

Suaeda sp are found in the adjoining saline ecosystem.

2. Wetlands of central and eastern Saurashtra

Saurashtra, the larger of Gujarat's two peninsulas extends from the port of Dwarka to the Gulf of Khambhat. All the significant wetlands are storage reservoirs created by damming small rivers or streams and salt pans.

Fauna

One hundred and thirty eight (138) species of water birds including Dalmatian Pelican, White eyed Pochard and Indian Skimmer were reported. The region is a major wintering area for pelicans, flamingoes, cranes and shorebirds.

Hiren Lake within the Gir National Park supports the largest known population of marsh crocodiles an endangered species.

Flora

The reservoirs generally lack abundant aquatic vegetation. Only patches of marsh vegetation or the reed beds remain. Vegetation of the catchments area is *Prosopis juliflora*, *Acacia nilotica* and *Azadirachta indica*.

C. Wetlands of North Gujarat

1. Nalsarovor Lake

Nalsarovor is the largest water bird sanctuary in the country and is one of the 15 wetlands identified by the National Committee on wetlands for intensive conservation.

One hundred and forty (140) species of water birds, nineteen (19), species of fishes, seventy six (76) species of invertebrates, seventy four (74) species of macrophytes, mostly terrestrial and forty (40) species of phytoplankton were reported in this area.

Fauna

All the listed threatened species of waterfowl in Gujarat are found here. Predatory finfish of Nal, like *Channa* sp, *Wallugo attu*, *Saccobranthus* sp etc are considered as resident species as they can survive under most adverse conditions.

Flora

Cyperus sp, *Typha angustifolia* are the emergent vegetation. Submerged vegetation such as *Najas gracilens* and *N. marina* occupies the open water zone. Other aquatic plants found are *Hydrilla* sp and *Vallisneria* sp. In puddles *Marselia* sp is encountered.

2. Wetlands of Sabarkantha and Banaskantha districts

Wetland of the area includes few tanks, reservoirs and small dams.

Fauna

Muval reservoir supports >5000 water birds.

Flora

Prosopis juliflora, *Mangifera indica*, *Tectona grandis*, *Melia azadirachta*, *Acacia arabica*, *Salvadora persica*, *S. Oleoides*, *Capparis aphylla* and *Zyziphus* spp are the common vegetation.

D. Wetlands of South Gujarat

1. Thol Dam, Ajwa, Wadhvana and Pavagadh Lakes

Thol is shallow water reservoir, which covers an area of 699.844ha. Water storage reservoirs and tanks with some associated marshes in the vicinity of Vadodara and main land of Gujarat. These lakes are thought to be representative of the large number of small wetlands in eastern Gujarat and southern Rajasthan.

Fauna

These tanks and reservoirs support >45,000 water birds. Among them about 900 are Pelicans during January 1998. Ajwa Lake supports marsh crocodile the endangered species.

Flora

Acacia nilotica, *Zizypus* sp, *Acacia leucocephloea*, *Azadirachta indica*, *Ficus* sp, *Salvadora* sp, *Prosopis juliflora*, *Capparis* sp are the important tree species in and around Thol dam.

In other lakes seventeen (17) species of macrophytes were reported. The dominant emergents are *Ammania baccifera*, *A. multiflora*, *Bergia* sp, *Alternanthera sessilis*, *Cyperus* sp, *Scirpus* sp, *Polygonum plebeium* and *Marcelia egyptica*. Floating and submerged aquatic species include species of *Chara*, *Potamogeton*, *Najas*, *Vallisneria*, *Nymphaea*, *Limnanthemum*, *Lemna*, *Wolffia* and *Hydrilla*.

MANGROVES AND COASTAL ECOSYSTEMS IN GUJARAT

Mangroves constitute a significant part of tropical coastal biodiversity. They are found throughout Tropical Asia, where they occupy more than 75,000 km², or 40% of the world's total area of mangroves. Indonesia alone, with 42,530 km², accounts for 23% of the world total; India (with 6,700 km²), Malaysia (with 6,424 km²), and Bangladesh (with 5,767 km²) each have over 3% of the world total. Over the past few decades, mangrove forests in Tropical Asia have declined considerably as a consequence of human activities. The Philippines and Thailand have experienced reductions of 60% and 55%, respectively, over 25 years. Between 1980 and 1990, the area of mangroves declined by more than 37% in Viet Nam and more than 12% in

Malaysia. These figures suggest a loss of nearly 7,500 km² of mangrove forests in these four countries alone representing more than 4% of the current global total.

The total area under mangroves in Gujarat is 911sq.km (FSI 2001). Gujarat has the second largest patch of mangroves after W. Bengal. A decrease of 120sq.km of mangroves in a short time span of 2 years has been noted from the FSI estimations. However the reason behind the reduction of mangrove coverage requires sensible justification by thorough study of the mangrove areas in the state.

Both west and southern regions of the coast is surrounded by 10-13km wide marshy zone occupying the inter tidal limits and drained by the muddy channels in which the sea flows at low tide to join the main creeks. The swampy coast is dotted with mangroves wherever the depth at high tide does not exceed a certain limit. The mangrove formations on this coastline are isolated or discontinuous and occur from Kandla, Navlakhi in the north to Jodia, Jamnagar, Sikka, Salaya and Okha along the coast of Gulf of Kachchh.

The Gulf of Kachchh (GoK) is the largest Gulf in the entire West Coast, covering an area of about 7350 km². The depth of this gulf varies from 20-60 meter, with a mean of 30 meter. A negative water balance characterizes the GoK, where the evaporation exceeds the sum of precipitation and river runoff (**Table 2**). However, large quantities of sediments from River Indus (in Pakistan) get moved along the Kachchh peninsula and slowly accumulate. This compensates the nutrient deficiency in gulf water due to poor runoff condition. The salinity of GoK increases from mouth to upstream from 35 to 40 ppt. The interaction of physical and chemical characteristics of the GoK, however, creates suitable habitat conditions for diverse life forms in the gulf, especially in the southern side.

The dry climatic condition prevails in the region for about 8 months in a year

(eg, In Jamnagar the thermal amplitude is 120C and average rain is 470mm), poor rainfall and human interferences acts as limiting factors to mangrove vegetation in the Kachchh although the estimated coverage is about 213sq.km.

A. Gulf of Kachchh - Coastal Ecosystem

Gulf of Kachchh, (7,350sq.km) is the major marine system along the southern boundary of Kachchh aligned approximately East-West; the gulf is about 170 km long and 75 km wide at the mouth. While the southern coast of GoK is fringed by extensive mud flats, the northern coast mainly formed the tidal flats.

Table 2. Basic Hydrography of Gulf of Kachchh and Khambhat

Parameters	Kachchh	Khambhat
Area (km ²)	7350	3120
Depth Range (m)	20-60	15-45
Depth Mean (m)	30	20
Volume (Mm ³ yr-1)	220,000	62,400
River Runoff (Mm ³ yr-1)	140	38,000
Rainfall (Mm ³ yr-1)	3087	3500
Evaporation (Mm ³ yr-1)	7350	1560
Water Balance (Mm ³ yr-1)	- 4123	Positive
Turnover Time (days)	8-51days (Decreasing upstream)	4-15days (Increasing upstream)
Tides (m)	Jakhau-Kandla 3-8m (Increasing upstream) Okha-Jamnagar 3-5m (Increasing upstream)	Jafarabad-Khambhat 3-12m (Increasing upstream) Umbargoan-Luhara Point 6-10m (Increasing upstream)
Tidal expanse (km)	Jakhau-Kandla 0.5-2km (Increasing upstream) Okha-Jamnagar 1->5km (Increasing upstream)	Jafarabad-Khambhat 1.5-5km (Increasing upstream) Umbargoan-Luhara Point 2-8km (Increasing upstream)

Source: Coastal and Maritime Environments of Gujarat: Ecology and Economics, 2000, Gujarat Ecology Society, Vadodara.

1. Western Mangroves in Kori Creek and near Jakahu

Along the 410 km long coastline of Kachchh, mangroves are distributed in the form of narrow discontinuous patches and covered about 727km² area (GEER, 1999). This is more than 75% of the total mangrove area of Gujarat. In Kachchh, dense and sparse mangroves covered about 344 km² and 383 km² areas, respectively. While, the best mangrove patches are found in Kori creek and area around Jakhau coast, there are few remnant

patches in the coastal areas of Mundra, Anjar and Bhachau talukas (GEER, 1999). This is because the Kori creek and Jakahu areas are very close to the international border and thus have relative difficult accessibility and get higher degree of protection against biotic pressures. In these areas the trees gain a height of more than 5 meters.

Fauna

Eighty-six (86) species of water birds, One hundred and forty five (145) species of fish and three (3) species of mammals were

reported. Among the fishes 13 species are of endangered/vulnerable category. Dolphins, Whales and Dogongs found are from the endangered list. Endangered species like Dalmatian Pelican, Indian Skimmer, Spotted billed Pelican are reported.

Among the invertebrates Giant sea anemone (Vu), *Bonnellia* (R&En), Sea urchin (Th), flat worms and sea worms (Vu) are important.

Three (3) species of sea turtles Leather back turtle, Green turtle and Olive Ridley are available in these waters.

All the species of corals are threatened. *Acropora* sp are endangered and probably extinct. Endangered soft coral *Paracyanthus indicus* is also reported.

Flora

While Kachchh has the maximum mangrove cover in the State, it displays very low diversity in mangrove species with 8 species. The area has only one dominating mangrove species—*Avicennia marina*. Other species like *Rhizophora mucronata*, *Ceriops tagal*, *Avicennia officinalis*, *A. alba*, *Bruguiera gymnorhiza*, *Sonneratia apetala*, *Aegiceros corniculatum* are found in very small proportion.

The mangroves in Kachchh in general are of open scrubby type with low wooded *Avicennia marina* and *Rhizophora mucronata*. In Dwarka, Poshitra and Dohlani mostly single species *Avicennia marina* is seen.

2. Marine National Park

Mangroves of the Marine National Park (MNP) constitute the second largest patch of mangroves in Gujarat. Extending up to 11,000 ha, these mangroves represent the richest area in Gujarat comprising six species of mangrove. Many island in MNP like Pirotan, Bhaidar and Dhani have good mangroves. However due to the presence

of several major ports and refineries, the mangroves are under constant anthropogenic pressure. A study conducted in 1998-1999 (Space Applications Centre (ISRO), Ahmedabad and Remote Sensing and Communication Centre, Gandhinagar) revealed degradation of a large mangrove patch measuring up to 1,600 ha.

3. Shravan Kawadia-Land locked mangrove ecosystem

Shravan Kavadia is a land locked patch of 0.7ha mangroves located at about 40km in the northeast direction of Bhuj. Most of the trees were damaged in 1998 cyclone. The partially damaged or top broken surviving trees count thirty-six. Average stand height was measured 18.5m and the average girth about 240cm. The unique inland mangrove patch is an evidence of the ancient shoreline proving the historical evidence for geomorphologic change in the region at a rate of 1.3cm/year is obvious due to the Holocene transgression of the sea.

4. Sea grass beds and algal communities

The extent of sea grass beds is very limited in Gujarat and is restricted to the Gulf of Kachchh. *Cymodocea ciliata* and few other species are only found.

Gujarat has recorded more than 200 species of seaweeds. There are about 39 species of red algae (Rhodophyceae), 25 species of green algae (Chlorophyceae) and 25 species of brown algae (Phaeophyceae) in marine National Park. Most of the algal formations are observed between the coastal stretches of Okha to Piraton Island. Genera *Valonia* sp, *Porphyra*, *Caulerpa*, *Ulva*, *Padina*, *Acetabularia*, *Boodlea*, *Halimeda*, *Dictyopteris*, *Asperopsis*, *Gracillaria*, *Enteromorpha*, *Sargassum* are found and are threatened. Sea weeds notably agarophytes (*Gracellaria acerosa*, *Gracillaria* sp), alginophytes (*Sargassum*, *Cystosiera*, *Turbinaria*) and

carageenophytes (*Hypnea*, *Halemenia*) are exploited in the gulf.

5. Coral reef ecosystem

Coral reefs are found only in Gulf of Kachchh, occupied an area of 53sq.km in 1985 and can be divided into three types: rock pool, eulittoral and submerged reefs. Rock pool reef are found in small temporary pools located on the top of the knife edged barren rocks, sprinkled at high tide with small scattered colonies of encrusting coral species of the genera *Favia* and *Montipora*.

Eulittoral reef has a rugged topography with very small pools having discontinuously distributed coral species of the genera *Turbinaria*, *Montipora*, *Favia*, *Leptoria*, *Porites*, *Leptastrea*, *Gonipora* and *Goniastrea*. The submerged reefs can be further classified into four zones: shoreward reef, surface reef, surface reef and oceanic reef. Coral composition of submerged is from genera *Turbinaria*, *Montipora*, *Porites*, *Leptastrea*, *Gonipora*, *Goniastrea*, *Favia*, *Leptoria*, *Podabacia*, *Pavona* and *Hydnophora*. *Acropora* sp and other branching corals are rarely present in the Gulf. Huge quantities of the dead tufted branches of *Acropora* found in this region may be representing the luxuriant growth of branched corals in the past.

The gulf holds 40 species of coral fauna. Among the 15 reef islands, Okha, Sholi Gujar, Dona, Borlia, Saga, Goose and Piraton consists higher diversity of corals. Species such as *Favia favius*, *Goniastrea pectinata* and *Cyphastrea serailia* are very common in islands; other species like *Psammocora digitata*, *Acropora* sp, *Montipora* sp, *Siderastrea* sp are common.

6. Industrial and development Pressure

Jamnagar district has attracted the highest investment of 31% of the state in industrial and petrochemicals. Fifty percent of the

total industrial units are concentrated in Anjar taluka. Similarly 69% small-scale industries are concentrated in Jamnagar. Another influencing industry at Kachchh is Salt.

B. Gulf of Khambhat-Coastal Ecosystems

1. Gulf of Khambhat

The Gulf of Khambhat, (3,120sq.km) is aligned in a north-south orientation. It is marked by the huge interaction of saline and fresh waters, providing it the characteristics of an extended estuarine system. The coastal belt (20km) passes through as many as 6 districts and 19 talukas. The coastal area is about 11,000 sq.km.

Due to the unique oceanographic features, the Gulf of Khambhat is the least explored region in oceans around India. Rapid and significant geomorphic changes have been observed during the last two decades. There have been shoreline changes due to erosion and deposition processes, which is accelerated not only by natural geological agents but also through developmental activities.

The Gulf has a unique distinction of having world's highest tidal amplitude of about 11m that has potential of generation of energy and other dangers as well. The average precipitation varies from 600mm on the western side to 800mm on the eastern side. However, about 9000km² around the Gulf shows a high concentration of inherent salts in the sediments and ground water has higher salinity reaching 2000ppm and above (Table 5). Bharuch and Bhavnagar are the major salt producing districts of the state.

Extensive mudflats, estuaries and creeks with high regime, large quantities of sediment transport characterize the Khambhat coast. There are extensive areas of inter tidal mud and sand flats, coastal salt marshes and degraded mangrove

associations, particularly in the deltas of the Mahi and Sabarmati rivers.

Fauna

Sixty-two (62) water birds were reported from the area, which includes the endangered Indian Skimmer. This area supports >50,000 water birds.

Two marine species of turtle *Chelonia mydas* and *Lepidochelys olivacea* both endangered were reported to be nesting in large numbers along the coast and on Piram Island.

Flora

The main vegetation are *Juncus* sp, *Fimbristylis tenera*, *Typha angustata*, *Ipomoea cornea*, *Commelina forkalei*, *C. bengalensis*, *Ker gavl*, *Echinocloa colonum*, *Cyperus iriaai*, *Cyperus difformis*, *C. compressus*, *Citrus colocynthis*, *Tradescantia axillaries*, *Sphaeranthus indicus*, *Physalis minima*, *Oxalis corniculata*, *Mimosa pudica*, *Lacera sp*, *Hibiscus cannabinus*, *Heliotropium supinum*, *Chenopodium murale*, *Caesulia axillaries*, *Celosia argentea*, *prosopis juliflora* and *Cestrum equisetifolia*.

Formerly extensive tracts of mangroves were found, which were now left to few hectares. Gulf of Khambhat is not rich in mangrove vegetation and accounts for five per cent of the total mangroves of the state. Along the entire coastline of Gulf of Khambhat the major mangrove patches are observed in Bhavnagar (19sq.km), Bharuch (12sq.km) and Surat (41sq.km) districts.

2. Algal community

In Gulf of Khambhat algal formations are restricted to Mahuva and Gopnath area. The common genera are *Enteromorpha*, *Ulva* and *Gracillaria*. Mahuva and Gopnath have a favorable rocky inter tidal shoreline.

3. Industrial and development Pressure

Groups of chemical, petrochemicals, drugs and pharmaceuticals industries are concentrated on the coastal districts of Bharuch and Surat. Industries that contribute significantly towards water pollution such as chemicals, textiles (dyeing), and other industries that have implications like rubber and its products, glass, clay and cement are concentrated in Ahmedabad district except the major textile units that are concentrated at Surat. Bharuch and Bhavnagar are the major salt producing districts of this region.

Five new ports at Mithivirdi, Dholera, Hajira, Vansi and Borsi are to be developed by private sector and one at Dahej to be developed by Gujarat Maritime Board.

C. Saurashtra Coastal Ecosystems

Encircled by the open sea, the Saurashtra coast is situated between two Gulfs (Long 68°58'-71°30' and Lat 22°15'-20°50'). The Saurashtra coast is divisible into two segments, the southwestern coast of Dwarka-Diu facing the Arabian Sea and the Southeastern coast of Diu-Bhavnagar.

The Dwarka-Diu segment stretches for about 300km and the coastline is trending NW-SE, from Dwarka to Veeraval with smooth and straight sandy beaches. The beaches are unusually calcareous and dominated by bio-clasts, the consolidated ancient equivalent of these biogenic sands are the famous miliolite rocks. The miliolite underlie the beach sands and occur as cliffs, wave cut platforms and submerged dunes, all along the shoreline indicating quaternary sea level fluctuations.

The segment Diu-Bhavnagar shows a transition from open sea to gulf environment stretching a length of 250km trending NE-SW between Diu and Talaja and almost N-S between Talaja and Bhavnagar. The abundance of tidal mud to the east of Diu points to the influence of

Gulf of Khambhat. The eastern coast extends up to Bhavnagar, beyond which it becomes the part of the Gulf of Khambhat. The Shretrunji River, which meets the gulf near Gopnath, forms a prominent estuarine delta at Saltanpur.

With gentle gradient the littoral zone is 0.5-1.5km wide and covered with loose calcareous sand. Long shore currents, high wave energy with surf action and tides generally low in the range of 2 to 3m characterize the coastline. The climate is semi arid with an average rainfall of 500 to 600mm.

The coastal belt (20km) passes through two districts, Junagadh and Amreli and 13 talukas. Out of the total fish production 645 tonnes 62 per cent production was reported from the fishing centers of Junagadh. There are two developed fishing harbors with allied shore facility at Veeraval and Mangrol and one more is added at Porbandar.

Fauna

Flamingoes, cranes and sea gulls are the common birds seen feeding in this area.

Hilsa ilisha, *Hilsa toil*, bombay duck, *Harpodon nehereus*, silver pompret, *Pampus argenteus*, Tiger shark, *Caleocerdo articus*, scianids, *Otolithus cuveri*, *Pseudosciaena diacanthus*, *O. brunneus*, *Sciaena glauca*, squid, *Loligo duvaucelii*, cuttle fish, *Sepiella inermis* are vulnerable due species specific targeted catches. Picking of mudskippers is a main livelihood activity in the muddy areas

Flora

Mangroves in the vicinity of Pipavav port are represented by only one species, *Avicennia marina*. The mangrove patch on the eastern side of the approach road to the Pipavav port showed comparatively good growth, growing up to 2-3m in height. However grazing pressure by camels, fodder collection for the cattle and fuel collection is more in this region. The stunted growth of mangroves is attributed

by the high salinity and grazing. A younger patch of mangroves with an average height of 1m can be observed on the western side of the approach road to port.

Vegetation such as *Ipomea pes-caprae*, *Sporobolus trinules*, *Fimrystylis* sp, *Crotolaria* sp, *Euphorbia nivuleria* are seen in the beach and dune areas.

Industrial and development Pressure

In Junagadh the industrial group that have greater dominance are glass, clay and cement, ferrous metal and food industry group and in Amreli it is ferrous metal, food and wood industries.

The existing ports like Porbandar, Veeraval, Jafrabad facilitate import/export of items such as coal, clinker, fertilizers and salt, fish, cement, soda ash, lime stone etc.

D. South Gujarat Coastal Ecosystems

South Gujarat coastline is situated around Long 72⁰50'E and Lat 20⁰30' and 20⁰07N. The coastal region of Gujarat is the smaller stretch of coastline (20km), passing through only four talukas of Valsad district and is characterized by high tidal amplitude of 8 to 9m. It is with narrow crescent beaches separated by seaward projecting headlands beyond Umbergoan. Inter tidal zone is made up of basaltic platforms with a veneer of mud. The climate is humid with a mean rainfall of 1800mm.

Fauna

The diversity is rich with 300 species of fin and shellfishes. Bombay duck, *Harpodon nehereus*, sciaenids *Otolithus cuveri*, *Johnnieops macrorhynchus*, *J. vogleri*, *J. glaucus*, *J. sina* and *Protonibea diacanthus* form the major catch. Squid, *Loligo duvaucelii*, cuttle fish, *Sepiella inermis* form the cuttle fishery. *Trichurus lepturus*, *Eupleurogrammus muticus*, *E. intermedius*, *Lepturacanthus salvata*, *T. auria*, *Panirus polyphagus* and *Thenus*

orientalis were forming the substantial percent of catch.

Flora

Mangrove forests in the coastal region accounts for a negligible share out of the total mangroves of the state. It is found along the mouth of Kolak estuary and in a small creek near Umbergoan. Dominated by *Avicennia marina* and a luxuriant growth of *Rhizophora* spp is observed in the south of Kolak River that attains height about 2m. Scattered mangroves are also found on the mudflats of Konai creek and some other creeks. Gujarat Ecology Society had suggested taking up plantation activities in south Gujarat coast, as the area is ideal with river run off, high tidal range, wide mudflats and good rainfall.

Industrial and development Pressure

Out of industrial investment of the state Valsad district has attracted 2.5 percent of the investments. The small-scale industrial sector is dominated by textile (13.3%), chemical (13.0%), group of industries and followed by Machinery except electrical and transport equipment (9.3%) and rubber and its products (7.6%). The coast does not have any major or minor port.

Valsad is one of the important fish producing districts of the state contributing about 9% of the total fish production. It ranks sixth as far as mechanized vessels are concerned (24% of the total). Out of the total 854 fishing villages, Valsad has 88 with 25% of the total fishing population of the state.

NATIVE COMMUNITIES OF GUJARAT

Fishermen and pastoralists are the two major community groups who have substantial dependence on the natural resources, very specifically on

biodiversity. Due to their dominant resource use pattern, they also play major roles in conservation of biodiversity.

1. Fishermen

According to the latest available figure total fishing population in Kachchh was about 15000 of which active ones were about 5700. The fishermen are mainly restricted in the coastal tracts. The fishermen who catch fish in the shallow, low tide water and most of them don't even have boats for deep-water fishing are the poorest among all fishermen communities and are locally known as 'Pagadiyas'. They sell their fish catch in the local markets. However, there are substantial numbers of fishermen own the boats, both mechanized and non-mechanized. Pagadiyas and boat fishermen, through their association, are in most of the cases using traditional fishing gears and follow some self-regulations in fish catching like seasonal breaks etc. Importantly, these fishermen community also closely associated with the mangroves and can also play major role in mangrove management.

2. Pastoralists and cattle breeders

In Kachchh, animal husbandry is a very common occupation. Both, settled and nomadic pastoralists exist here, commonly known as 'maldhari'. Based on the herd composition of livestock, there are clearly two distinct types of maldhari communities (a) those who keep cattle and buffaloes and (b) those who keep sheep and goats, belong to 'Rabari' and 'Bharwad' community. Although, milk selling is the main economic activity, but the sale of animal also form substantial contribution in the annual income of these maldhari communities. In Banni and Pachchham regions, traditional methods of livestock breeding still persists, especially for cattle and buffalo.

MAJOR PRESSURES IN THE COASTAL ECOSYSTEM

Industrialization and consequent urbanization has brought environmental degradation inland and pressures on the bio diversity of the coastal ecosystems. Gujarat is considered to be one of the most polluted states of India. From its traditional agriculture and textile base it has diversified into chemicals, petrochemicals, drugs and pharmaceuticals, food products, machine and tools, paper and pulp, dye stuffs, fertilizers etc.

The state has 41 minor, intermediate and major ports geographically dispersed across South Gujarat (13), Saurashtra (23) and Kachchh (4). Kandla-Vadinar is a major port in Kachchh. Ten new ports (Four in Kachchh and six in Khambhat areas) are to be developed by Private sectors and Gujarat maritime Board (GMB).

Dredging activities for vessel movements, sedimentation, shipping operations, solid and other waste deposition are the destructive pressures created to the sea floor, coastal habitats and other living organisms.

The pressure on the carrying capacity of the golden corridor is immense. Heavy concentration of industries without concern for the carrying capacity of the regions would result in the emergence of few more clusters such as Dahej or the Gulf of Kachchh, the latter threatening the fragile ecosystem of the Marine National Park.

A recent measure of setting up common effluent treatment plants (ETP) for the industrial units is an emerging threat. ETP's cannot treat certain types of pollutants like heavy metals, mercury and POPs. The disposal of hazardous waste and technical capability to measure the emission level need urgent attention.

The coastal waters of Gujarat can be expected to receive 606Mm³ domestic

sewage and 215Mm³ industrial effluents every year. In addition about 14000 tonnes of domestic solid wastes are dumped into the sea. Coastal industries generate five million tones of solid wastes. There is no estimates made for agricultural run off into the sea with increasing levels of pesticides and fertilizers from the districts of Kachchh, Kheda, Surat and Valsad that are likely to contribute excess nutrient. Pollution of estuaries and downstream rivers has affected the livelihood of the local fishermen.

Alang Ship breaking yard is the largest scrap yard in the world, has 182 ship-breaking plots spread over an area of 10km along the coast. This yard contributes 15 percent of India's annual steel production. Ship breaking yard at Alang generates large amounts of solid wastes, variety of pollutants, including fuel, oil and lubricants, heavy metals like tin and lead, chemicals like polychlorinated biphenyls from paints, oil sludge, fine powder and sand. The rich marine life on Piram Island is imperiled because of the accumulation of non-biodegradable wastes dumped into the Gulf of Khambhat.

Mining the extensive deposits of miliolite rocks of the quaternary period, overlain by calcareous beach sand, which are the raw material for soda ash and cement production, is a major threat to the miliolite beach and sandy shores of Saurashtra on the Arabian Sea. Soda ash plants in Mithapur, Porbandar and Sustrapada release enormous amount of wastewater with high contents of unionized Ammonia and inorganic suspended load.

In Porbandar, Valsad, Ankleshwar and Bharuch, Mangrol, Mandvi, Umbergoan and Pardi are likely to be the hot spots with textile industry being the main source of additional wastewater discharges.

Marine fish landings have exceeded the maximum sustainable levels.

The percentage of the commercially valuable varieties has fallen consistently over the years. While Gujarat accounts for about 30% of the marine food exports, its share of export earning is only about 10%. Regulation on the sustainable fishing practices including terms of mesh size and gears is urgent.

Mangroves and corals are under severe threat in Gulf of Kachchh. Species diversity of mangroves has virtually disappeared from the Gulf of Khambhat.

It is high time to act up on these crucial pressures to manage the environment besides economical development.

CONCLUDING REMARKS

Gujarat is one of the most diverse kinds of wetlands in the country including mangroves, coral reefs, beaches, mudflats, tidal flats, flood plain systems and fresh water lakes and reservoirs. However, industrialization and consequent urbanization has brought environmental degradation inland and pressures on the bio diversity of the coastal ecosystems. Thus, Gujarat is considered to be one of the most polluted states of India.

Wetland ecosystems are unique, biologically diverse systems recognized as valuable economic and environmental resources. Therefore, is essential to improve the capacity of the scientific community to tackle critical issues of great complexity and planetary relevance, such as the conservation and sustainable use of

the biodiversity of wetland ecosystems in Gujarat. A multidisciplinary approach is fundamental to the study of this complex biological community.

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