Biodiversity of Coastal Areas of Valsad, South Gujarat

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Abstract: ***The present study documents the diversity and quantitative assessment of fringing mangroves in these nine different estuarine regions of Valsad district of South Gujarat. The most outstanding feature of our study is that we observed four species of mangrove and sixspecies of mangrove associate namely Avicennia marina, Sonneratia apetala, Salvadora persica, Acanthus illicifolius, Ipomoea pes caprae, Sesuviarum portulacastrum, Clerodendrum inerme, Derris heterophylla, Cressa cretica,and Aeluropus lagopoides.The dominant mangroves in these areas are Avicennia species and Acanthus illicifolius.Earlier works included Rhizophora mucronata which was not found during this study in any of the nine spots of mangrove forests.We have used the Jaccardian similarity index to analysis the floral diversity of our mangrove sites. Our studyhighlighted the relation between water quality parameters, environmental and anthropogenic stress and speciescomposition and structures of mangrove.***

Keywords: Quantitative assessment, anthropogenic pressures,water quality parameter

1. Introduction

According to Chapman. 1976 coastal vegetation in India is categorized as – (1) marine algae(seagrasses) of littoral and sublittoral zone, (2) algal vegetation of brackish and saltwater marshes, (3) vegetation of sand dunes, (4) vegetation of drift lines, (5) vegetation of shingle beach, (6) vegetation of coastal cliffs, rocky shores and coral reefs (containing macroalgae), (7) mangrove vegetation in saline intertidal soil. This zonation of vegetation in the coastal andestuarine area is due to the specific environmental gradient(Del Moral and Watson. 1978; Disraeli and Fonda. 1979;Armstrong, Brändle and Jackson.1994; Ukpong. 1991). Based on inundation frequencies coast has three parts – one that is mostly covered by water(subtidal), one that is inundated by tidal waters(intertidal) and one that is inundated by only spring and neap tides(high tidal regions). The high tidal region has the maximum soil salinity,inhabited mangroves,and mangrove associates, beyondwhich is the ecotone containing herbs, shrubs,and climbers on the landward side.

Mangroves are salt–tolerant estuarine forest ecosystems of tropical and subtropical intertidal regions of the world (Banerjee and Ghosh. 1998)occupying 75% of the tropical coast of the world. Over the last few decades 50 % of original mangrove cover is lost (Spalding, Blasco,and Field. 1997).Now, these areas are categorized under ecological sensitive regions and under the jurisdiction of Coastal Regulation Zone (CRZ) (Jagtap, Moorthy,and Komarpanth. 2002).Mangroves are wonderful plants that have devised several morphological, physiological and biochemical adaptations.To cope with salt stress it hassalt-secreting glands, thick leaves to prevent water loss by transpiration, or stiff wiry leaves to resist sea spray,breathing roots pneumatophores to cope up with the anoxic condition of the soil. They are evergreen and have viviparous germination technique to avoid salt stress in germinating seeds, some of them also show leaf rolling movements in response to high temperature. Under normal salinity condition, Rubisco enzyme was extracted from the leaves andPEP carboxylase was extracted from the leaf under acute salt stress, which indicates that mangroves can change over from C3 to C4 photosynthesis under salt stress. Mangroves are prolific seed producer that has higher viability as compared to other types of plants, also they are quick to attain height and biomass (Alongi. 2002).

Though they breed sand flies and mosquitoes their benefits exceed their few disadvantages. Mangroves and mangrove associates are rich in biodiversity and are necessary from the ecological and economical point of view (Untawale.2006). The advantages of having mangroves are –(1)they can absorb more carbon dioxide than any tropical rain forest, (2)they are breeding spots of not only fishes but also many other arthropods,gastropods, crustaceans, mammals, birds, reptiles andshellfishes,(3) it indirectly supports many species of birds which are secondary and tertiary consumers that feed on these fishes and insects, (4)they act as barriers from damage from storms, tsunami and high tidal waves (Danielsen et al. 2005), (5)they also check coastal soil erosion by accumulating colloidal soil particles,(6) mangroves play an important role in below ground nitrogen cycling (Alongi et al. 2002),(7) they have a symbiotic association with many sulfurs reducing and iron reducing bacteria, (8) they prevent coral bleaching by reducing acidification of the sea, (9)mangrove litters are solubilized by fungi in soil (Prabhakaran and Gupta. 1990). This litter enhances the productivity of coastal water which leads to a huge diversity of. Decomposed leaves of mangroves are food for prawn and larvae of fishes. The decomposed leaf litter is a nutrient source which also gets exported to nearshore areas and utilized in the food web of that area (Sasekumar et al. 1992; Ewel, Twilley, and Ong. 1986).

Loss of biodiversity will destabilize the ecosystem as a whole (Solbrig. 1991 b). Restoration of mangroves will not only save the associated fishes and its predators but also the soil microbes that decompose the leaf litter.FAO has started several mangrove protection activities throughout the world. National Mangrove Committee has recommended areas where immediate attention is to be taken. For that, the estuarine areas should be declared a reserved forest, as was done by Goa Government and in Sunderban in West Bengal.

Mangrove Society of India has started a five-year management plan for Goa and there has been a tremendous increase in the wild flora and fauna in the area. According to NRSA (National Remote Sensing Agency, Hyderabad), India has 40 % of mangrove cover there has been an increase in the area of mangrove in Gujarat in 676km, which is quite encouraging. Mangrove plantation has been carried out in four districts of Gujarat namely Kutch, Baruch, Surat, and Anand with success by GIDR (Gujarat Institute of Developmental Research) on PPP model, (Public Private Partnership model) from 2002 to 2007. This work has been later merged with NREGA and already in action in the Kutch and Jamnagar area since last few years.

2. Methods

Location of Study area

Our study area Valsad district lies at 20* 37'N and 72* 55' E in Gujarat, India covering an area of 2,947 km^2. Valsad district has 5 major rivers and 4 minor rivulets that form a tributary of the main rivers or join the main rivers at their mouth to form a small estuarine delta. These mangroves as depicted in figure 1are found in estuarine regions in the mouth of rivers Auranga and Wanki (Site 1), Par and Kothar Khari (Site 2), Kolak (Site 3), Damanganga (Site 4), Kalu (Site 5), and Thumbi (Site 6) and in three minor creeks of Valsad district, at their mouth namely Lotus creek (Site 7), Maroli creek (Site 8), Bhandi creek (Site 9). The coast of Valsad district also has mangroves in the estuarine region of three taluks – Valsad, Pardi, and Umargaon. Our study site lies in the Gulf of Khambat in the western coast of India.

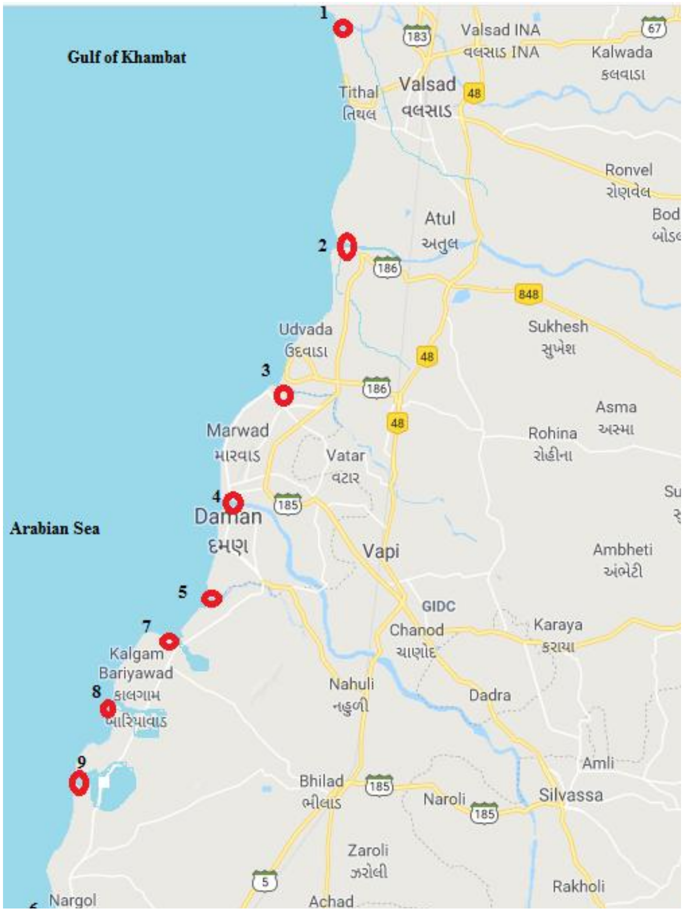

Figure 1: Mangrove study sites of Valsad district

Site1 – Auranga – Wanki river estuary, Site 2 – Par – Kothar river estuary, Site 3 – Kolak river mouth,Site4 – Damanganga river mouth, Site5 – Kalu river mouth, Site6 – Thumbi river estuary, Site 7 – Lotus pond creek, Site 8 – Maroli creek, Site 9 – Bhandi creek.

Description of the study area

Gujarat has got a long coastline of 1663 km with a subtropical climate. The continental shelf varies from 58 to 191 miles. Sea is normally calm except during the monsoon. Gulf of Khambhat is shallow with a water depth of 10m at tidal flats. The tidal range at estuary mouth varies from the 5-8 meter. When we talk about mangroves in Gujarat, we generally think of Kutch. Kutch and Jamnagar districts have 90 % of Gujarat mangroves. But there are many minor areas of mangrove trees and shrub forests in the mouths of various rivers and creeks of Valsad district of South Gujarat which has a coastline of 63km. The coastal wetland ecosystem of Valsad includes mudflats, floodplains, tidal flats, coral reefs, and beaches. Valsad has several perennial rivers that form mixed estuaries, where tidal current is strong having semidiurnal tide and there is a weak discharge of fresh water. In spite of repeated damming for agricultural purposes these rivers mouths still, have mangroves. Mangrove trees were also observed in certain relatively inaccessible areas upstream of the mouth of the river of all rivers. Several creeks are also present of which we have mangroves in Fansa, Maroli,and Bandhni, some creeks are used in salt farming and has sparse mangroves.The estuarine area of Valsad is an open mangrove region. They have high density and abundance during the monsoon which fluctuated in a close range during the drier months of summer and winter. ENVIS biodiversity data showed that the mangrove region of Valsad district was never dense in the past also.

Field survey

A field survey was taken every fifteen days in the pre-monsoon, monsoon, and post-monsoonfor a period of two years.Three twin line transect method was used for trees and three twin belt transect method was used for herbs and shrubs (Nirmal Kumar et al. 2010).For trees,two 30 m line transects were used(Villarreal et al. 2013 andKardani et al. 2014) with 10 m gaps between the two line transects. All trees that touched the line were counted and their circumference at breast height was taken and averaged.For herbs and grasses, a 5m x 5m quadrant was used in a twin belt transect method, along a 30 m line quadrants were placed at regular intervals of 5 m.The anthropogenic and environmental pressure on the mangroves observed during field trips were noted, as well as information was also taken by interacting with the local village fisherman folks. These data were compared to various previous research works as well as with the annual data of GEC on South Gujarat wetlands and also previous papers to understand the change in species diversity and relative abundance of species.

Chemical

Water samples were collected from the mouth of the river of three rivers that have abundant water even the driest of the month. Water samples were collected every fifteen days for a year. The sample was collected from a depth of 60 cm as subsurface water has stable water quality parameters. Parameters that were used – heavy metal concentration

(Chromium, Lead, Aluminum, Zinc, Boron, Iron.), pH, Sulphide, Electrical conductivity (EC), Sulphate, Dissolves oxygen (DO), Biological oxygen demand (BOD), Total hardness as $CaCO_3$,Chemical oxygen demand (COD), Total dissolved solids (TDS), Chloride. Some of the parameters like pH, Electrical conductivity, Dissolves oxygen (DO) were determined in situ and others were in the laboratory by standard methods of IS3025- 1987.

The formula for the calculation of Frequency, Density, Relative Density, and Abundance are

Frequency = ((Number of units in which a species occurred / Number of units studies)) ×100

Density = (Total number of individuals of species in all the sample units / Total number of sample units studied)

Relative Density = ((Number of individuals of species in all the sample units / Number of individuals of all species in all the sampling units)) ×100

Abundance = (Number of individuals in all sampling units / Number of units in which species occurred)

3. Result and Discussion

Vegetation Type

Mangrove vegetation found during our field study is noted in table 1. Identification of plants was done in consultation with the manual of Banerjee, Shastri, and Nayar. 1989 and Blasco and Aizpuru. 1997. During our study, it was noted that most of the mangroves plants of our study sites belonged to the regeneration class (having a CBH less than 50 cm) and a few recruitment class (with CBH between 50 cm and 1m). Maximum CBH (the circumference at breast height) indicating mature trees of recruitment class was found in Nargol mangroves and Damanganga River and Kolak River mouth. Minimum CBH regeneration class was found in Par River were mainly regeneration class.

There is a zonation of mangrove vegetation. Riverbank mudflats harbor only *Avicenna* shrubs while the *Avicennia* trees are found towards the firm land intermingled with *Sonneratia* and *Salvadora* and *Acanthus* bordering them on the landward side. On the other hand,*Acanthus illicifolius* can be found on land bordering the mature trees of *Avecennia marina*, *Salvadora persica*, and *Sonneratia*species.

The environmental gradients that lead to zonation of coastal vegetation are – (1) soil texture (Bentley. 2014), (2)soil drainage (Mendelssohn and Seneca. 1980), (3) soil aeration (Burdick and Mendelssohn. 1987), (4)inundation frequency (Disraeli and Fonda. 1979), (5)salinity(Snow and Vince. 1984), (7)nutrient toxicity(McKee, Mendelssohn and Materne. 2004). Among all these factors periodic inundation and saline water table are most important to determine species diversity of an area (Kim and Ihm. 1988).

In earlier research work many species such as *Rhizophora mucronata*, *Bruguiera gymnorhiza*, and *Ceriops tagal* were found in the estuarine areas of Purna Sanctuary in Navsari district of south Gujarat, though very rare. During my recent field study in Valsad district of South Gujarat, only *Avicennia marina*, *Salvadora persica*, *Sonneratia apetala*,and*Acanthus illicifolius* can be round all of which are most tolerant species among mangroves. Mangroves which have a narrow range of habitat condition such as *Rhizophora* was not found in the area. No epiphytes and lichens were found during our study. All this indicates anthropogenic stress.

Quantitative Parameters

Site 1, Auranga - Wanki estuary has a monoculture of *Avicennia* with a frequency of 80 and a density of 16.8. Since it is a monoculture the relative density is 100 and abundance is 21. This site has monospecific strand and that too in regeneration class indicates anthropogenic pressure induced vegetation homogeneity.

Site 2, Par – Kothar estuary has four species of mangrove. *Avicennia* has a maximum frequency of 70 among the four species, while *Acanthus* has a maximum density of 5.4, the relative density of *Salvadora* is maximum of 75.38 and *Acanthus* has the maximum abundance of 27.

Site 3, Kolak river mouth has a frequency of 100 for *Avicennia*. *Avicennia* also has the highest density, relative density, and abundance amongst the other two species. Other species found there were*Salvadora* and *Acanthus*. Mangroves density in one bank of Kolak river mouth were high where the fisherfolk has created a raised platform to go to the river mouth directly. Presence of such mature trees indicates that climatic conditions are favorable for the growth of mangroves, if not subjected to human stress.

Site 4, Damanganga river mouth has four mangrove species of which *Avicennia* has the maximum frequency, density, and relative density. *Acanthus* has a maximum abundance of 26.66.

Site 5, Kalu river mouth has a monoculture of *Avicennia*, but its least density and since it is a single mangrove species site so the relative density was 100 %. The occurrence of a single type of mangrove in Kalu and Auranga site indicates either there is stress or a secondary succession has started. But in this study site, many mature trees of *Avicennia* were found which indicated that condition for mangrove growth is present and there has been denudation of land due to partial deforestation of the study site.

Site 6, Thumbi river estuary four mangrove species was noticed, of which *Avicennia* has the maximum frequency and relative density. Low abundance was observed due to extensive chopping of trees and the existence of vast mudflats.

Table 2, shows the quantitative parameters of mangrove diversity. *Avicennia* is the most frequent mangrove in all sites and *Sonneratia* is least frequently found. Maximum tree density was observed in Nargol and Damanganga indicating less stress and maximum shrub density was observed in Auranga river estuary. We have not considered the three creeks as the creeks have very sparse, low-density mangroves so doing the line transect was not feasible. As a whole mangrove species diversity is very low and discontinuously distributed. Though all the creeks had very sparse mangrove bushes, the lowest number of shrubswere observed in Fansa creek.

Mangrove associate found are listed in table 3. All these halophytic mangrove associates occur away from the water source on hard ground and showed seasonal fluctuation. Seven main associated halophytes are *Clerodendrum inerme*, *Sesuviarum lagopides*,*Ipomoea pres capre*, *Cressa cretica*, *Derris trifoliata*,and*Aeluropus lagopoides.* Several species of Cyperus such as C *rotundus* and C *difformis* towards the landward side of the estuarine region. *Alternanthera philoxeriodes* are quite common in these areas during post-monsoon dry periods. Species diversity of the mangrove associate at various sites was homogenous.

All the three creeks have good fresh water inlet from minor streams and had submerged aquatic vegetation. Table 4, enlists the species diversity submerged macrophytic vegetation of the creeks which contained mangrove at their mouth. In the creek, we find a distinct zonation of vegetation. In the head region, we find a variety of submerged and floating aquatic plants. Presence of these aquatic plants is an indicator that there is abundant freshwater input. These aquatic plants are not at all detrimental for mangroves present at the mouth of these three creeks. The inflow of both fresh and brackish water makes these creeks unique in vegetation. The creeks are surrounded on three sides by grasslands and on one side by mangroves. The main stress in these creeks is mangrove chopping for firewood and to clear the ground for salt making. This will reduce aquatic plants of the creeks and will cause salt water ingression.

Factors essential for the growth of mangrove

Table 5 shows various climatic factors essential for mangrove sustainability and those present in our study site. It is noted that all the major climatic factor that is needed for survival and growth of the mangroves are present in Valsad district except soil pH which is a bit more alkaline in some sites. Table 6 shows various water quality parameters of three major rivers that have deep water throughout the year. Here we notice that water in all the three sites are slightly alkaline which is not a problem as mangroves tolerate alkaline water. Electrical conductivity is a measure of the salinity. Our study sites have moderate salinity, which is not a problem as mangroves are salinity tolerant. Light metals are micronutrients for plants. Mangroves are an accumulator of heavy metals and are quite resistant to it in trace concentration. Dissolved oxygen of water is a function of the level of organic material in water. Mangroves are tolerant of the anoxic condition. Mostly *Avicennia*is present in our study sites which have pneumatophores to take oxygen directly from the air. All these conditions are conducive for a biodiversity-rich coastland and estuarine ecosystem.

Table 1: Mangrove found in Valsad district of South Gujarat

Study Area	*Scientific name*	*Common name*	*Family*	*Average CBH, cm*	*Average Density**	*Dicot/ Monocot*	*Phenology Flowering*	*Shrub/ Tree*
Site 1	*Avicennia marina*	White mangrove	Acanthaceae	15.6	21	Dicot	March to June	Both
Site2	*Avicennia marina*	White mangrove	Acanthaceae	14.2	5	Dicot	March to June	Shrub
	Sonneratia alba	Sweet-scented apple	Lythraceae	13	8	Dicot	February to June	Trees
	Acanthus illicifolius	Holly left acanthus	Acanthaceae	NA	27	Dicot	April to December	Shrub
	Salvadora persica	Toothbrush tree	Salvadoraceae	NA	11	Dicot	March to June	Both
Site 3	*Avicennia marina*	White mangrove	Acanthaceae	38.1	27	Dicot	March to June	Both
	Salvadora persica	Tooth brush tree	Salvadoraceae	NA	4	Dicot	March to June	Tree
	Acanthus illicifolius	Holly-leaved Acanthus	Acanthaceae	NA	17	Dicot	April to December	Shrub
Site 4	*Avicennia marina*	White mangrove	Acanthaceae	58.2	15	Dicot	March to June	Both
	Salvadore persica	Toothbrush tree	Salvadoraceae	NA	11	Dicot	March to June	Tree
	Sonneratia alba	Sweet-scented apple	Lythraceae	19.8	14	Dicot	February to June	Tree
	Acanthus illicifolius	Holly-leaved Acanthus	Acanthaceae	NA	17	Dicot	April to December	Shrub
Site 5	*Avicennia marina*	White mangrove	Acanthaceae	34	5	Dicot	March to June	Both
Site 6	*Avicennia marina*	White mangrove	Acanthaceae	98.6	25	Dicot	March to June	Both
	Salvadora persica	Toothbrush tree	Salvadoraceae	NA	12	Dicot	March to June	Both
	Acanthus illicifolius	Holly left Acanthus	Acanthaceae	NA	10	Dicot	March to June	Shrub
Site 7	*Avicennia marina*	White mangrove	Acanthaceae	NA	5	Dicot	March to June	Shrub
Site 8	*Avicennia marina*	White mangrove	Acanthaceae	NA	2	Dicot	March to June	Shrub
Site 9	*Avicennia marina*	White mangrove	Acanthaceae	NA	1	Dicot	March to June	Shrub

* Average number of plants per transect

Table 2: Quantitative parameters indicating floral diversity

Site	Species found	Frequency (%)	Density	Relative Density	Abundance (%)
Site 1	Avicennia	80	16.8	100.0	21
Site 2	Avicennia	70	3.5	24.5	5
	Sonneratia	40	3.2	22.4	8
	Acanthus	20	5.4	37.8	27
	Salvadora	20	2.2	15.4	11
Site 3	Avicennia	100	27.0	74.6	27
	Salvadora	20	0.8	2.2	4
	Acanthus	50	8.5	23.4	17
Site 4	Avicennia	73	11.0	58.9	15
	Salvadora	20	2.2	11.8	11
	Sonneratia	7	0.9	5.0	14
	Acanthus	27	4.5	24.3	17

Site 5	Avicennia	60	3.0	100.0	5
Site 6	Avicennia	90	22.5	67.8	25
	Salvadora	60	7.2	21.7	12
	Acanthus	20	2.0	6.0	10

Site1 - Auranga Wanki river estuary; Site 2 - Par- Kothar estuary; Site 3- Kolak river estuary; Site 4- Damanganga river estuary; Site 5- Kalu river estuary; Site 6- Thumbi river estuary; Site7–Lotus creek; Site 8- Maroli; Site 9- Bandhni creek.

Table 3: Mangrove associate found in Valsad district of South Gujarat

Scientific Name	*Vernacular Name*	*Family*	*Site 1*	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Site 6*	*Site 7*	*Site 8*	*Site 9*
Thespasea populnea	Indian tulip tree		+	+	+	+	+	+	+	+	+
Ipomoea pes capre	Beach morning glory	Convolvulaceae	+	+	+	+	+	+	+	+	+
Tridex procumbens			+	+	+	+	+	+	+	+	+
Sesuviarum lagopoides	Sea purse lane	Aizoaceae	+	+	+	+	+	+	+	+	+
Clerodendrum inerme	Glory bower	Fabaceae	-	+	+	+	+	+	+	+	+
Derris trifoliata	Pan lata	Fabaceae	+	+	+	+	-	+	+	+	+
Ipomoea carnea			-	+	+	-	-	-	+	+	-
Cressa cretica	Rudravati	Convolvulaceae	+	-	+	+	+	+	-	-	-
Typha agustata			-	+	+	-	-	-	-	-	-
Colocasia			-	+	+	-	-	-	-	-	-
Aeluropus lagopoides	Khariyu gah	Poaceae	+	+	+	+	+	+	+	+	+
Dactyloctenium aegypticum			+	+	+	+	+	+	+	+	+
Echinocloa crusgallis		Poaceae	+	-	-	-	-	-	-	-	-
Echinocloa colona		Poaceae	+	+	+	+	+	+	+	+	+
Chloris barbata		Poaceae	+	-	-	+	-	-	-	-	-
Cynodon dactylon		Poaceae	+	+	+	+	+	+	+	+	+
Cyperus rotundus	Nut grass	Cyperaceae	+	+	+	+	+	+	+	+	+
Cyperus difformis	Rice sedge	Cyperaceae	+	+	+	+	+	+	+	+	+
Alternanthera philoxeroides	Alligator weed	Amaranthaceae	+	+	+	+	+	+	+	+	+
Alternanthera bettzikiana		Amaranthaceae	+	+	+	+	+	+	+	+	+
Alternanthera ficoides		Amaranthaceae	-	-	-	-	-	-	+	-	-
Alternanthera pungens		Amaranthaceae	-	-	-	-	-	-	-	-	+
Alternanthera tenella		Amaranthaceae	-	+	+	+	-	-	-	-	-
Alternanthera sessilis	Sessile joyweed	Amaranthaceae	+	+	+	+	+	+	+	+	+

Table 4: Submerged vegetation in the three creeks

Scientific name	*Common name*	*Family*	*Site 7*	*Site 8*	*Site 9*
Echinocloa crassipes			+	-	-
Potamogeton natans	Broadleaf pondweed	Potamogetaceae	+	-	-
Hydrilla verticillate	Water thyme	Hydrocharitaceae	+	-	-
Cyperus rotundus	Nutgrass	Cyperaceae	+	+	+
Cyperus iria	Tufted sedge	Cyperaceae	+	+	+
Cyperus difformis	Umbrella sedge	Cyperaceae	+	+	+
Nelumbo nucifera			+	-	-
Nymphea carulea			+	-	-
Nymphea pubesens			+	-	-
Nymphea alba	Water lily	Nympheaceae	+	+	+
Zostera	Marine eel grass	Zoosteraceae	+	-	-
Zizaniya aquaticus	Wild rice	Poaceae	-	+	+
Vallisneria spiralis	Tape eel grass	Hydrocharitaceae	+	-	-
Ceratophyllum demersum	Coontail	Ceratophyllaceae	+	-	-
Chara	Chara		+	-	-
Ipomoeaaquatic	Water spinach	Convolvulaceae	+	+	-
Alternanthera philoxeroides	Alligator weed	Amaranthaceae	+	+	+

+ Present, - Absent

*Site 1 – Auranga Wanki river estuary, Site 2 – Par – Kothar river estuary, Site 3 – Kolak river mouth,Site4 – Damanganga river mouth, Site5 – Kalu river mouth, Site6 – Thumbi river estuary, Site 7 – Lotus pond creek, Site 8 – Maroli creek, Site 9 – Bhandi creek

Table 5: Environmental Factors essential for mangrove growth and regeneration

Parameter	*Required by Mangrove**	*Valsad district Environmental Condition*
Rainfall, cm	200 - 300	100 – 433
Atmospheric humidity, %	60 - 90	52 – 93
Temperature, ^{o}C	19 - 35	15 – 35
Soil pH	5.3 - 6.9	6.2 - 9.1

*Data from Blasio, 1977; Naskar and Mandal, 1999

Table 6: Yearly Average Water Quality of three rivers at the river mouth

Water Quality Parameters	*Damanganga river*	*Par river*	*Kolak river*
pH	7.24	7.1	7.11
Dissolved Oxygen(mg/l)	4.4	4.4	4.9
Electrical Conductivity (us/l)	3,060	2,877	2,013
Chloride(mg/l)	799	373	323
Sulphate(mg/l)	251	331	128
Hardness(mg/l)	1536	521	453
Heavy metals(mg/l)	0.05	<0.05	<0.05
Light metals (micronutrients) (ppm)	1.73	1.5	1.82

Land use pattern in the estuarine area

In Table 7, we highlighted the area wise land use pattern so that we can understand the critically degraded mangrove site and area suitable for reforestation. The maximum estuarine area is in Tumbh River but most of it is in the form of an intertidalmudflat, so much of this area can be used for afforestation with the extreme salinity tolerant *Avicenna*. Maximum area under mangrove vegetation is in Par- Kothar estuary and Damanganga estuary. Maximum degradation of mangroves due to deforestation was observed in site 1 where the deforested area is replaced by mud flat with *Aeluropus lagopoides*.Site 8 and 9 has much of its area under salt farming. Site 7 has the least area under mangrove. Site 5 has an entire area under mangrove but it receives a very low amount of fresh water from the Kalu river.

Stress Factors

A notable thing observed during the field survey was that the estuarine mangroves are succeeded by xerophytes species like *Acacia*, *Prosopis* species due to various anthropogenic pressure such as the land use pattern change. Also, the mangroves are quite thin at places with stunted growth. Mangroves in our area are facing some anthropogenic stress. Water quality and other environmental factors are not creating much plant stress. Table 8, highlights the site-specific stress factors at various mangrove sites of Valsad district so we can find a site-specific solution for mangrove preservation.

Most common stress in all sites is chopping of trees for various purpose such as clearing ground for parking of fishing boats and creating aquaculture ponds in all the sites. The use of dragnet, gillnet, and mechanized boats in fishing ports like Maroli, Fansa, Nargol, Umargaon, Kothar, and Umarsadi causes the destruction of propagules of mangroves. Coastal and estuarine lands have been converted to agricultural lands for plants such as rice cultivation, coconut plantations, mango, chikoo, and *Casuarina* plantation. Salt fields were found in only three creek areas.

Repeated damming of the rivers and choking of plants by polythene are the major anthropogenic stress factors for mangroves in our study sites. Repeated damming of several rivers as mentioned earlier may be one of the causes of the disappearance of *Rhizophora* which was reported in earlier reports.

River pollution is also a major factor for dwindling mangrove in South Gujarat. In Valsad district, huge agricultural runoff occurs from the agricultural areas in Dharampur and Khaprada hills during the monsoon. Detergents, pesticides, and fertilizers used by the village folks are the major pollutants in the upper reaches that affect mangroves down in the mouth of the river. Due to recent rapid industrialization in Sarigam and Vapi effluent from CETP dumped into the rivers, which are deleterious for mangroves. Mangroves are hyperaccumulator of pollutants and heavy metals are worst effect by river pollution. Stray cattle, crabs and other insects badly damage the pneumatophores of mangroves. The estuarine area is also used for open defecation and most of the propagules and seedlings are trampled by humans, so don’t get a chance to grow a tree. All these factorshave contributed to making the mangrove ecosystem of Valsad fragile.

Jaccardian Index

Jaccardian similarity cluster analysis was applied in our floral diversity analysis to cluster our nine mangrove study sites based on the similarity of species distribution. From table 9, we observe that river mouth plant diversity (site 1 to 6) is different from the creek plant diversity (site 7, 8 and 9). Creek at site 7 is floristically different from the rest of the sites. Site 7 has abundant fresh water, hence supports diverse floating, submerged plants as well as diverse grasses and sedges throughout the year. Such abundance absent in the other creeks. Among the creek sites, site 8 and 9 has almost 90 % similarity which can be due to the same level of salinity as both these sites are used in salt mining. Creek sites are thus sub - clustered into two groups one containing only site 7 and other containing sites 8 and 9. River mouth can be sub clustered into two subgroups containing site 1, 5 and sites 2, 3, 4, 6 due to change in land use pattern. The first river cluster containing site 1 and 5. These sites have massive deforestation, site 1 has been deforested long ago as is obvious from the new seedlings are seen to grow out in some of those places and site 5 is having recent deforestation hence no regeneration of trees observed. Site 2, 3,4 and 6 has similar species composition as these sites have less deforestation but much damage is done to mangrove propagules by fishing trawlers in these three sites.

Jaccardian similarity index reflects that the land use pattern is related to plant diversity. Sites with the same type of human interference have the same type of vegetation. Our study sites are thus clustered into three groups – site 1 to 6, site 7 and site 8, 9. Reclamation of saline soil has been done earlier by *Salvadora*can also be done in the creeks

Table 7: Land use pattern in the estuarine area (%)

Site No.	Mangrove area, %	Mudflat area, %	Aquaculture area, %	Deforested area, %	Salt production area, %
Site 1	13	43	0	43	0
Site 2	74	24	2	0	0
Site 3	44	56	0	0	0
Site 4	38	62	0	0	0
Site 5	98	0	0	2	0

Site 6	8	92	0	0	0
Site 7	1	99	0	0	0
Site 8	17	29	0	0	54
Site 9	8	46	0	0	46

Table 8: Stress factors at various mangrove sites at Valsad district

Sites	AnthropogenicPressure
Site 1	Deforestation for parking space for trawlers and fishing boats, repeating damming of rivers, sea barriers to protect against rough tides, dumping of industrial effluent, dumping of municipal waste, timber harvesting.
Site 2	Deforestation for parking space for trawler and fishing boats, aquaculture and prawn culture, repeating damming of rivers, sea barriers to protect against rough tides, dumping of industrial effluent, dumping of municipal waste, timber harvesting.
Site 3	Deforestation for parking space for trawler and fishing boats, aquaculture and prawn culture, repeating damming of rivers, dumping of industrial effluent, dumping of municipal waste, timber harvesting.
Site 4	Deforestation for parking space for trawler and fishing boats, repeating damming of rivers, dumping of industrial effluent, dumping of municipal waste, timber harvesting
Site 5	Deforestation for parking space for trawler and fishing boats, deforestation for coconut plantation, sea barriers to protect against rough tides, timber harvesting.
Site 6	Deforestation for parking space for trawler and fishing boats, aquaculture and prawn culture,
Site 7	Deforestation for parking space for trawler and fishing boats, deforestation for creating space for mango and chikoo plantation, salt mining, timber harvesting.
Site 8	Deforestation for parking space for trawler and fishing boats, aquaculture and prawn culture, salt mining, timber harvesting.
Site 9	Deforestation for parking space for trawler and fishing boats, aquaculture and prawn culture, salt mining, timber harvesting.

Table 9: Jaccardian Similarity Index for mangrove sites

	Site 1	*Site 2*	*Site 3*	*Site 4*	*Site 5*	*Site 6*	*Site 7*	*Site 8*	*Site 9*
Site 1		0.64	0.67	0.75	0.80	0.77	0.50	0.71	0.73
Site 2	0.64		0.96	0.85	0.69	0.81	0.51	0.69	0.64
Site 3	0.67	0.96		0.81	0.72	0.84	0.53	0.71	0.67
Site 4	0.75	0.85	0.81		0.74	0.87	0.49	0.67	0.68
Site 5	0.80	0.69	0.72	0.74		0.85	0.53	0.77	0.80
Site 6	0.77	0.81	0.84	0.87	0.85		0.53	0.75	0.77
Site 7	0.50	0.51	0.53	0.49	0.53	0.53		0.65	0.55
Site 8	0.71	0.69	0.71	0.67	0.77	0.75	0.65		0.86
Site 9	0.73	0.64	0.67	0.68	0.80	0.77	0.55	0.86	

*Site 1 – Auranga – Wanki river estuary, Site 2 – Par – Kothar river estuary, Site 3 – Kolak river mouth,Site4 – Damanganga river mouth, Site5 – Kalu river mouth, Site6 – Thumbi river estuary, Site 7 – Lotus pond creek, Site 8 – Maroli creek, Site 9 – Bhandi creek

4. Conclusion

Most mangrove vegetation belonged to regeneration class. A maximum number of mangrove shrubs belonging to regeneration class were found in Auranga site indicating anthropogenic interference. A maximum number of mature trees belonging to the recruitment class were found at Nargol, an ideal site for reforestation. Among mangroves,*Avicennia* was most abundant and among mangrove associate,*Cressa cretica* and *Derris heterophylla* were most abundant and in creeks, most abundant hydrophytes were *Chara* and *Ceratophyllum*. Environmental condition and water quality of the river and creeks were conducive for the growth of mangroves. This district gets good rainfall also so none of the rivers dry up. This district has tremendous potential to develop mangrove forest, which can be used to promote ecotourism in Gujarat. Valsad district has two hardy mangrove species, *Avicennia* which comprise 45 % of Indian mangroves and *Acanthus ilicifolius*, a very hardy spiny shrub is protected against herbivory. After this study, we can easily predict the areas which have the potential to support the reforestation and ecotourism. Valsad's mangrove areas if declared reserve forest or sanctuary, then all flora, fauna and microbial diversity can be protected from further damage. Reforestation can be done on public-privatepartnership and involving the local folks by making them aware of the benefits of mangroves in the estuarine areas of Valsad.A comprehensive action plan to reduce stress factors mainly chopping of mangroves due to various reasons could only be solved by educating the local farmers and fishing folks of the benefits of having mangroves. Salt mining if stopped from site 8 and 9 can increase the mangrove density in those creeks.

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