RESEARCH REVIEW JOURNALS
Volume-03
Issue-12
December -2018

ISSN: 2455-3085 (Online)
RESEARCH REVIEW International Journal of Multidisciplinary
www.rrjournals.com [UGC Listed Journal]

Survey of Coastal Vegetation around Gulf of Cambay-Gujarat, Using Remote Sensing and Geo Informatics Tools

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ARTICLE DETAILS

Article History
Published Online: 10 December 2018

Keywords
GIS, Remote Sensing, Coastal, Mangroves, vegetation, LISS III, Gujarat

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ABSTRACT

Monitoring species diversity is a useful positive management practice to assessing damage to the system and good species diversity. The paper reports the wetland plants in some coastal areas of Gulf of Cambay, Gujarat. The survey was conducted in 2011-2014 and collected specimens were deposited in the Herbarium of the Department of Botany, Gujarat University.

Mangrove area map were prepared using unsupervised classification techniques of LISS III and IV satellite data for the year 2010 to 2013. The *Avicennia marina* is the common dominant species of all the area. Present investigation was done along the coast line of entire Gulf area covered by 7 Districts viz Bhavnagar, Ahmedabad, Anand, Bharuch, Surat, Navsari and Valsad. They were studied by undertaking extensive field work.

The result revealed that total 113 wetland plants under 94 genera and 56 families were recorded. The total 14 mangrove species were documented throughout the study.

1. Introduction

Gujarat has the longest shoreline of about 1663 km. The Gujarat coast provides a wide variety of coastal features due to its varied physiography, geomorphology, coastal processes and river discharge into the sea. Coastal landform supports a large variety of flora and fauna at the coast and adjoins area form a unique ecosystem owing to combined influence of both fresh and saline water (Pawar, 2012, Bhatt *et al,* 2009). Wetland plants provide bio resources and have crucial direct economical and ecological functions (Misra, *et al*, 2012). Plants growing in between the highest and the lowest tidal limits may be considered 'mangrove' (Tomllinson, 1932, Ellison *et al*, 1999) The tropical estuarine ecosystem comprise of mangrove forest which support the varieties of Habitat and environmental quality of the ecosystem (Twilley *et al*, 1996). Gujarat Mangroves are falls under Coastal, brackish water and Estuarine mangroves in the inter tidal zones along with mouths of minor rivers or minor estuaries and back waters, facing Arabian sea by North-East to West and East to West directions (Mandal *et al*, 2008). Coastal ecosystem provide essential source of food security of developing countries, also provide habitat for wide variety of associated species and make available livelihood for local community (Loffoley *et al* , 2009, Baptiste *et al* ,2006, Macintosh *et al* ,2002, Nirmal Kumar *et al*, 2011). Apart from all the functional role these unique habitat have been facing tremendous threat owing to construction of aquaculture pond, harbor extension, overgrazing, industrial pollution, Urbanization and other land use practices (Mandal *et al*,2008, Saravanan, 2008, Balachandran *et al*, 2009). In the present study, the entire gulf area was demarcated and all the vegetation falling under the study was sampled in 2011.

2. Materials and Methods

Study site

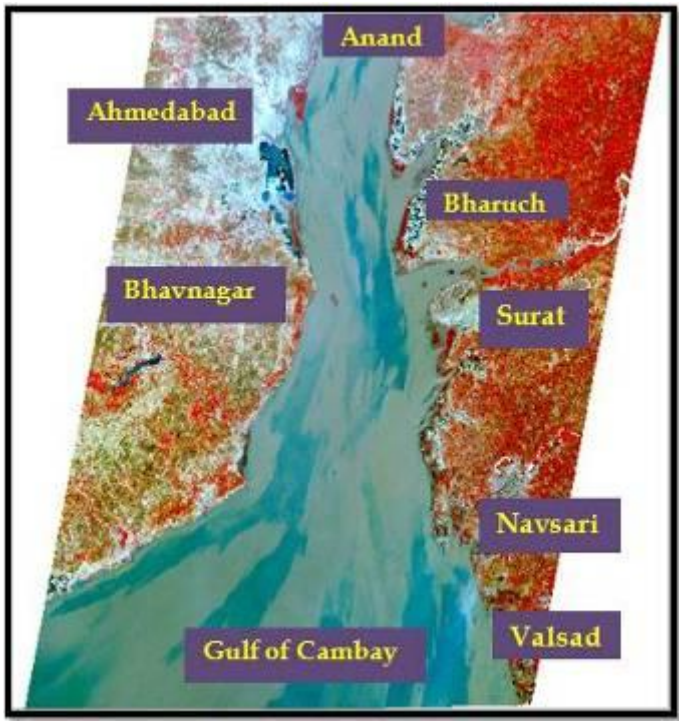

Figure 1 Satellite Image (LISS III & IV) of study area

The Gujarat is a unique state has longest coastline of about 1640km long which is one third of the coastal length of the country comprising two Gulfs namely Gulf of Kuchchh and Gulf of Khambhat. Gulf of Khambhat is located approximately between latitude 20 30' and 22 20' N and longitude 71 45' and 72 53' E. It is 70 km wide and 131 km. long located between Saurashtra peninsula and mainland Gujarat. The

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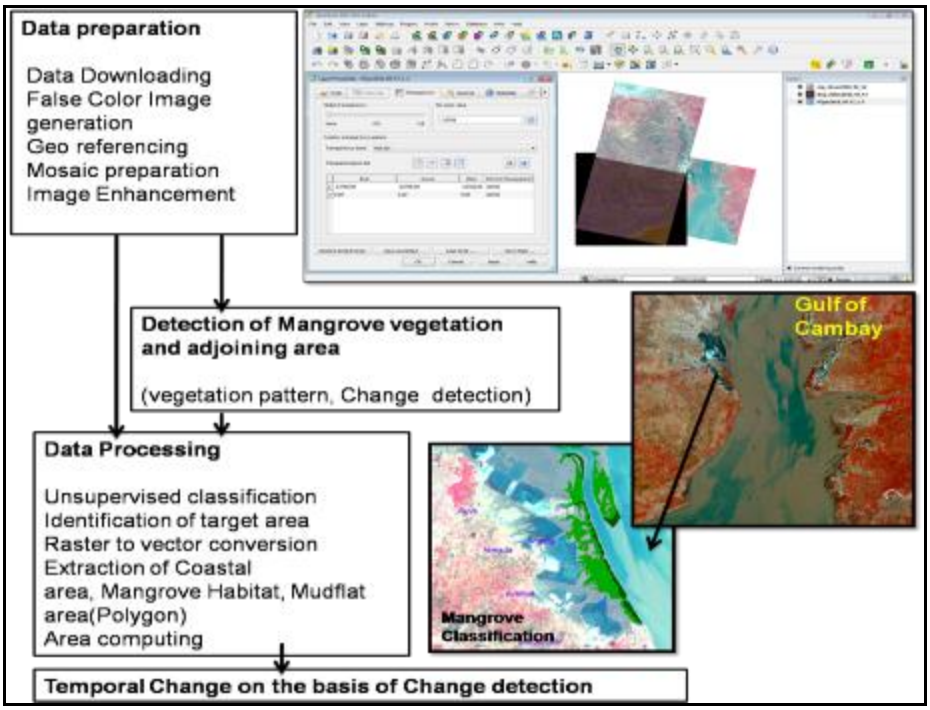
study area characterized by large and small rivers *viz* Sabarmati and Mahi (Northern end), Tapi, Auranga, Dhadhar etc. opens in gulf draining down water and alluvium to the gulf and coastal area (Balagurusamy *et al*, 2011). The rocky beaches are common from Mahuva to Gopnath, reducing towards Ghogha and Bhavnagar. A few sandy patches are also observed intermittently.

Vegetation Study methodology

Each district was surveyed physically and the floristic diversity of coastal vegetation was studied. The area of monitoring unit was taken during lower tidal condition, referring tide table before the survey. In the current study, satellite Image of Indian remote sensing satellite (IRS) P6 of sensor of LISS III and LISS IV were used to analyze for mangrove vegetation mapping and monitoring changes in cover in the Study area. A general survey of the vegetation was made and observed different plants forms like Halophytes, Mangroves and Mangroves Associate etc. Apart from the study of vegetation, plant species were collected and specimen of each species was identified and mounted on Herbarium sheets, and also photographs were taken of particular specie.



3. Results and Discussion

Mangrove species flourish in particular ecological conditions, which are the key factors for the growth and diversity of mangroves. Diversity of mangroves can be an indicator of the environmental condition of that area. Greater diversity of mangroves is thus an indication of the favorable and conducive ecological conditions of the region.

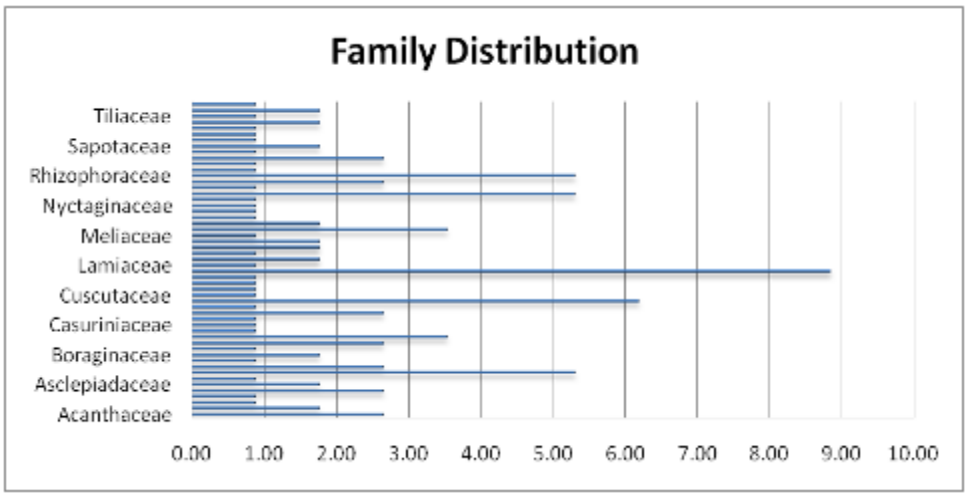


Figure 2. Family wise Distribution

The diversity study is based on the field surveys taken over the whole study throughout the duration of the work done. The estuarine areas and the islands were traversed randomly, making an inventory of the species inhabiting them. The studies were chiefly made for the mangrove species and the mangrove associates. Mangrove associates are the plants that

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grow in the same habitat as of the mangroves, but which lack some of the key deciding features which place mangroves separately from the rest of the vegetation. Mangrove associates include the salt marsh vegetation and the grasses that grow over the mudflats. The list of the mangrove species and the associated species encountered during the study is given in the result table. Equating moderately dense mangrove of Forest Survey of India (FSI, 2011) with moderately dense mangrove of present assessment a net decrease of 7km^2 is recorded while; equating open mangroves of FSI, 2011 with present assessment a net increase of 28 km^2 is recorded. It is observed that moderately dense areas are subsequently decreasing (7 km^2) because of many development activities taken place at this fragile ecosystem. During the survey following mangroves species and mangrove associates are reported.

Table 1 Total mangrove species

Scientific Name	Family	Present Study	IUCN category (2013)
Avicennia alba Bl.	Avicennaceae	N, Bh, S	LC
Avicennia marina (Fosrk.) Vierh	Avicennaceae	B, S, N, V, Bh, D	LC
Avicennia officinalis L	Avicennaceae	N, V	LC
Acanthus ilisifolius L	Acanthaceae	S, N, V	LC
Aegiceras corniculatum (L.) Blanko	Myrsinaceae	V	LC
Bruguiera gymnorhiza (L.) Saving	Rhizophoraceae	V	LC
Bruguiera cylindrical (Linnaeus) Blume	Rhizophoraceae	V	LC
Ceriops tagal Arnold	Rhizophoraceae	B, N,V	LC
Kandelia candel (L.) Druce	Rhizophoraceae	S	LC
Lumnitzera racemosa Willd.	Combretaceae	V	LC
Rhizophora mucronata Lam	Rhizophoraceae	B, N,V	LC
Rhizophora apiculata Blume	Rhizophoraceae	V	LC
Sonneratia apetala Buch.-Ham	Sonneratiaceae	S,N,V	LC

B- Bharuch, Bh-Bhavnagar, D-Dhandhuka, N- Navsari, S- Surat, V-Valsad , LC- Least Concern

Coastal vegetation

After the completion of survey total eight Monocots and ninety Dicots are observed from the diverse coastal areas. The inventory of coastal diversity is below.

Table 2 Total mangrove associates

Scientific Name	Family	Present Study
Abrus precatorius L.	Papilionaceae	S, V
Acacia nilotica (L.) Del.	Mimosaceae	B, S, N, V
Acacia chundra (Roxb.exRottl.)Willd.	Mimosaceae	S, N, V
Adansonia digitata L.	Bombacaceae	B, Bh, N, V
Aegle marmelos (L.) Corr. Serr	Rutaceae	B, N,V
Aeluropus lagopoides (L.) Trin. Ex Thw.	Poaceae	B,Bh,D,N,S, V,
Alianthes excelsa Roxb.	Simaroubaceae	D, B, S,N
Aloe vera (L.) Webb.& Berth.	Liliaceae	B, Bh, S, V
Alternanthera sessilis (L.) D.C.	Amaranthaceae	S, N, V
Ampelocissus latifolia (Roxb.) Panch.	Vitaceae	V
Anisomeles indica (L.) O.Ktze.	Lamiaceae	S, N, V
Asparagus racemosus Willd.	Asparagaceae	V
Azadiracta indica A. Juss.	Meliaceae	B, Bh, S, N, V
Azima tetracantha Lam.	Salvadoraceae	N, V
Bauhinia racemosa L.	Caesalpiniaceae	V
Blemea mollis (D.Don.) Merr.	Asteraceae	V
Blepheris mederaspatensis (L.) Roth.	Acanthaceae	V
Borhavia verticillate Poir.	Nyctaginaceae	V
Bothriochloa intermedia (R.Br.) A. Campus.	Poaceae	B, S, N, V
Butea monospperma (Lam.) Taub.	Papilionaceae	V
Cadaba fruticosa (L.) Druce.	Capparaceae	V
Caesalpinia crista L.	Caesalpiniaceae	N, S, V

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Calotropis procera (Ait.) R.Br.	Asclepiadaceae	S, N, V
Capparis deciduas (Forsk.) Edgew.	Capparaceae	S, V
Capparis sepiaria L.	Capparaceae	V
Cardiospermum halicacabum L.	Sapindaceae	V
Carissa congesta Wt. Icon.	Convolvulaceae	S, N, V
Cassia tora L.	Caesalpiniaceae	S, N
Casuarina equisetifolia L.	Casuriniaceae	V
Ceiba pentandra (L.) Gaertn.	Malvaceae	V
Celastrus paniculatus Willd.	Celasraceae	S, N
Chloris barbata SW. Fl.	Poaceae	B, Bh, D, S, N, V
Cleome viscose L.	Capparaceae	S, N
Clerodendrum inerme (L.) Gaertn. F.	Verbenaceae	D,N,S,V
Clitoria ternatea L.	Papilionaceae	V
Cocculus hirsutus (L.) Diels.	Menispermaceae	S, N, V
Cocos nucifera L.	Arecaceae	B, Bh, S, N, V
Coldenia procumbens L.	Boraginaceae	Bh, D, V
Cressa cretica L.	Convolvulaceae	B, Bh, D, S, N, V
Creteva nurvala Buch. Ham.	Capparidaceae	V
Crotolaria filipens Bth.	Fabaceae	V
Cuscuta reflexa Roxb.	Cuscutaceae	V
Cyamopsis tetragonoloba (L.) Taub.	Fabaceae	V
Cyperus rotundus L.	Cyperaceae	Bh, D, S, N, V,
Derris indica (Lamk.) Bennet.	Fabaceae	S, N, V
Dioscorea bulbifera L.	Dioscoriaceae	S, N, V
Ficus benghalensis L.	Moraceae	Bh, B, S, N, V
Ficus religiosa L.	Moraceae	Bh, B, N, V
Grewia abutifolia Vent.	Tiliaceae	V
Heliotropium strigosum Willd	Boraginaceae	V
Hemidesmus indicus (L.) R.Br.	Periplocaceae	S, N
Hygrophila auriculata (Schum.) Heiene.	Acanthaceae	S, N, V
Hyphaene indica Becc.	Arecaceae	V
Ipomoea aquatic Forsk.	Convolvulaceae	N, V
Ipomoea fistulosa Mart.	Convolvulaceae	S, N, V
Ipomoea obscura (L.) Ker-Gawl.	Convolvulaceae	V
Ipomoea pes caprae (L.) R.Brown.	Convolvulaceae	Bh, D, S, N, V
Ipomoea pes tigridis L.	Convolvulaceae	V
Ixora pavetta Andr.	Rubiaceae	N, V
Jetropha gossypifolia L.	Euphorbiaceae	V
Lantana Camara L.	Verbenaceae	V
Lawsonia inermis L.	Lythraceae	Bh, D, V
Malincara Zapota (L.) P. Royen.	Sapotaceae	S, V
Malinkara hexandra (Roxb.)Dub.	Sapotaceae	S, N, V
Mangifera indica L.	Anacardiaceae	Bh, S, V
Melitolus indica (L.) All.	Fabaceae	V
Moringa oleifera Lam.	Moringaceae	S, N, V

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Opuntia elatior Mill.	Cactacae	S, N, V
Parthenium hysterophorus L.	Asteraceae	V
Pentatropis capensis (L.f.) Bullock.	Asclepiadaceae	V
Pespalidium geminatum (Forsk.) Stapf.	Poaceae	B, Bh, D, S, N, V
Phoenix sylvestris (L.) Roxb.	Arecaceae	D,S,N,V
Pithecellobium dulce (Roxb.) Bth.	Fabaceae	V
Polygonum plebeim R.Br.Prodr.	Polygonaceae	V
Porteresia coarctata (Roxb.) Tateoka.	Poaceae	B, N,S,V
Prosopis cinenraria (L.)Druce	Mimosaceae	S, V
Prosopis julifera (Sw.) Dc.	Mimosaceae	B, Bh, D, S, N, V
Salvadora oleoides Decne.	Salvadoraceae	B, V
Salvadora persica L.	Salvadoraceae	B, Bh, D,N,S,V
Salicornia bractiata	Chinopodiaceae	B,
Sesbania cannabina (Retz.) Pers.	Papilionaceae	B, Bh, D, S, N, V
Sesuvium portulacastrum (L.) L.	Aizoaceae	Bh,D, N, V
Solanum pyracanthon Lam	Solanaceae	V
Suaeda monoica Forssk. ex J. Gmelin	Chenopodiaceae	Bh, D, S, N, V
Suaeda nudiflora Roxb.	Chinopodiaceae	B, Bh,D, S, N, V
Tamarindus indica L.	Tamaricaceae	B, Bh, D, S, N, V
Tamarix indica Willd.	Tamaricaceae	Bh, D, S, N, V
Teramnus labialis (L.F.) Spreng.	Fabaceae	V
Thespesia populnea (L.) Soland.	Malvaceae	S,N,V
Tinospora cordifolia (Willd) Miers.	Manispermaceae	V
Tridax procumbens L.	Asteraceae	S
Urginea indica (Roxb.) Kunth.	Liliaceae	S, N, V
Urochondra setulosus (Trin.)Hubb.	Poaceae	B
Vernonia anthelmintica (L.) Willd.	Asteraceae	Bh, D, V
Vernonia cineria (L.) Less.	Asteraceae	Bh, D, V
Xanthium strumarium L.	Asteraceae	Bh, D, V
Zizyphus mauritiana Lam.	Rhamnaceae	V
Zizyphus nummularia (Brum.f.) W. & A.	Rhamnaceae	S, N, S
Zizyphus xylopyra (Retz.)Willd.	Rhamnaceae	V

B- Bharuch, Bh-Bhavnagar, D-Dhandhuka, N- Navsari, S- Surat, V-Valsad

4. Conclusion

During the floristic survey total eight mangroves species were observed from the Valsad district. The floristic diversity is maximum in Valsad among the all district because of this region has better fresh water inflow of the Damnganga, the Auranga and the Par river. In Navsari and Surat District total six mangroves species recorded in which *Avicennia marina* (Fosrk.) Vierh was the dominant. In Surat, development of aquaculture and saltpans industries also poses a serious threat to this vegetation. In olpad taluka fishing activity and saltpan industries are very common as a result of this large no of mangrove habitat on risk. In Damka and Dumas village (Surat) plenty of mangroves are cut down to develop electrical pole. Dholai fishing port area in Navsari, dence Avicennia patch is observed. Total 7 species of mangroves reported from the Purna esturine in Navsari. In Bharuch field survey, natural mangrove forest of *Avicennia marina* (Fosrk.) Vierh only the dominant species. However, in some are *Ceriops tagal* Arnold and *Rhizophora mucronata* Lam plantation achieved by forest Department. In Jambusar , Nada and Devjagan villages millions of saltpans are constructed owing these areas are suffering with high salinity and least vegetation. Near Dahej port (Bharuch) less no of mangrove vegetation observed as a consequence of major industries expansion. Large no of mangrove plantation were taken by Gujarat Forest Department. However, Floristic diversity is very less in this region only *Avicennia marina* (Fosrk.) Vierh and *Avicennia alba* Bl was naturally occurring species. Mangroves species are occupy at different areas of wetland. The dominant species *Avicennia marina* (Forsk.) Vierh. var. marina occurs as a fringe mangrove and is seen on the high tidal mudflats areas of all

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the selected sites. *Sonneratia apetala* Buch. Ham is present on most of the intertidal mudflats and grows abundantly along the creeks of Surat, Navsari and Valsad areas. *Acanthus ilicifolius* L. is found growing along the landward fringe of the intertidal area and shallow creeks. This species is only mangrove species which grows on hyper saline areas of Surat, Navsari and Valsad. *Ceriops tagal* (Perr.) C.B. Roinson and *Bruguiera cylindrica* (L) Bl. plants are found on the intertidal mudflats and behind fringe patches of *Avicennia marina* (Fosrk) Vierh. *Rhizophora mucronata* Lam. is present dispersed along the intertidal mudflats of Bharuch, Navsari and Valsad area. In this study are large numbers of mangrove sapling and mudflats area are observed which represent the good regeneration status of mangrove species**.**

The villages' dependency on mangroves is high to meet the requirement of the fodder for cattle. Local people up rooted huge trees of mangroves and dried thereafter and used after about the year. Total 14 mangrove species and other coastal vegetation with their distribution is shown in table 1 and 2. Figure 1 shows the percent distribution of families during the survey.

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Figure.3 a- *Ipomoea pes caprae* (L.) R.Brown., b- *Acanthus illisifolius* L., c-*Dense mangrove patch in Surat,* d- Protective wall of Casurina in Umargam, e- *Aegiceras corniculatum* (L.) Blanko., f- *Avicennia marin,* (Fosrk.) Vierh.

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Figure 4. a- *Carissa congesta* Wt. Icon., b- *Clitoria ternatea* L., c- *Clerodendrum inerme* (L.) Gaertn. F, d- *Caesalpini crista* L., e- *Cressa cretica* L., f- *Alternanthera sessilis* (L.) D.C

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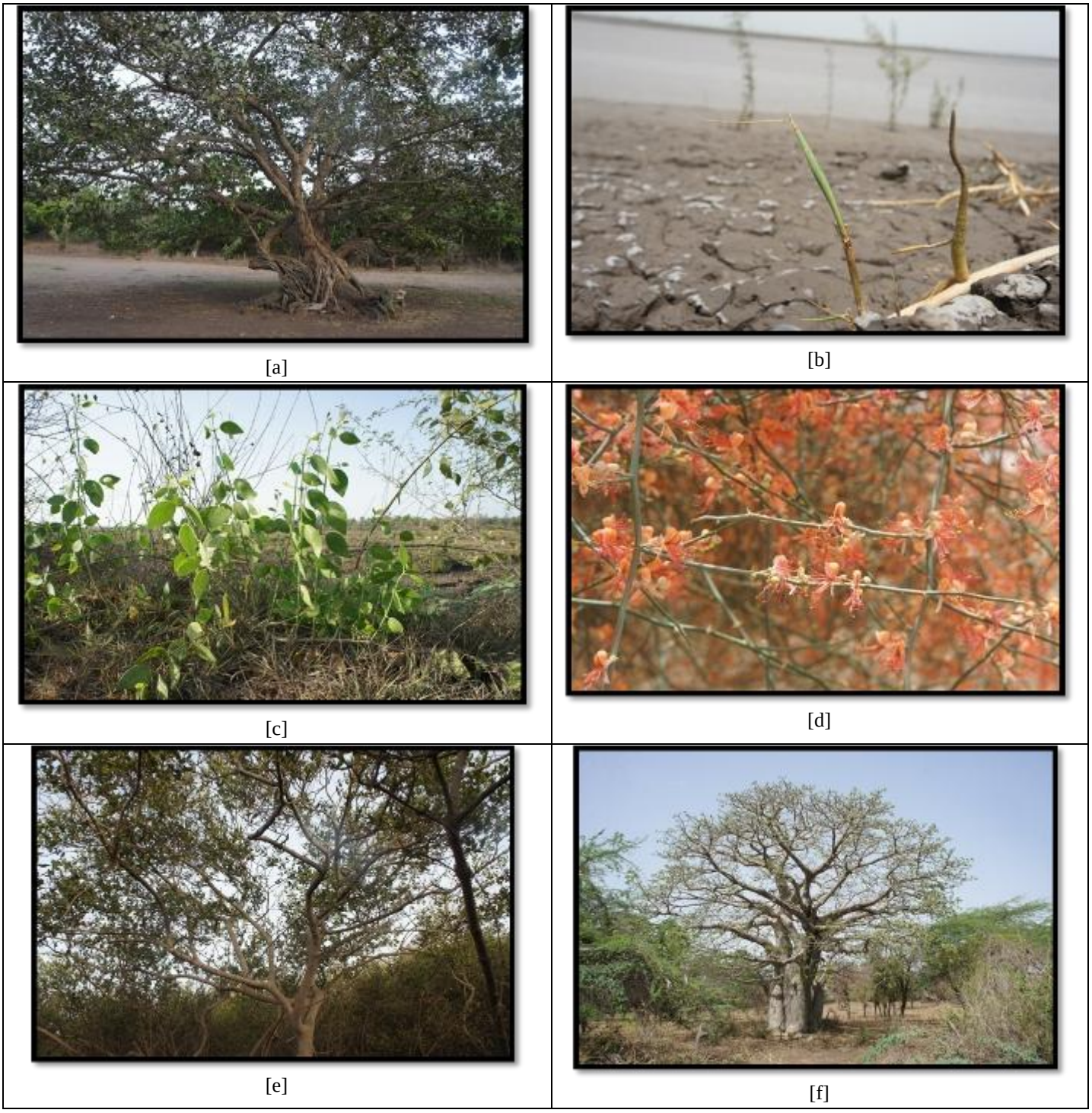

Figure 5 a- *Ficus benghalensis* L., b- Mangrove seed, c- *Salvadora persica L*., d- *Capparis deciduas (Forsk.) Edgew*., e- Avicennia tree, f- *Adansonia digitata L*.

Figure 6. Pressure on mangroves a and b- Mangrove destruction for fuel wood, c- Mangrove uprooted, d- Mangrove plantation by forest Department at Surat, e- mangroves leaves for livestock.

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