CMPA Technical Report Series

31

Floral Biodiversity Surveys for Baseline Assessment at Khijadiya Wildlife Sanctuary and Gosabara Wetland Complex in Gujarat

August 2016

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Indo-German Biodiversity Programme
Conservation and Sustainable Management of Coastal and Marine Protected Areas

CMPA Technical Report Series No. 31
Floral Biodiversity Surveys for Baseline Assessment at Khijadiya Wildlife Sanctuary and Gosabara Wetland Complex in Gujarat

Author
Dr. Padamnabhi S. Nagar, M.S.University-Baroda

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Responsible
Director, Indo-German Biodiversity Programme

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Disclaimer

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RESEARCH TEAM

Consultant

Padamnabhi Shanker Nagar

Reseach Scholars

Mital R. Bhatt

Karan G. Rana

Ajit M. Vasava

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Though, this appears to be an exhaustive list, we feel it to be much deficient. Therefore, we thank all those whose names might not have appeared here but of course, their cooperation and contributions made this work possible.

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1 INTRODUCTION

Wetlands are the area where saturation with water is dominant factor determining the nature of soil and the types of plants and animal communities living upon it. They are amongst the most productive ecosystems on the Earth (Ghermandi *et al.*, 2008), and provide many important services to human society (Ten Brink *et al.*, 2012). However, they are also ecologically sensitive and adaptive systems (Turner *et al.*, 2000). Wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics (Space Applications Centre, 2011). They cover diverse and heterogeneous assemblage of habitats such as lakes (Jheels), ponds, rivers, river flood plains, inter-tidal areas, estuaries, mangrooves, coral reefs and other related ecosystems.The prolonged presence of water creates conditions that favor the growth of specially adapted plants and promote the development of characteristic wetland (hydric) soils.

Wetlands were categorised into marine (coastal wetlands), estuarine (including deltas, tidal marshes, and mangroove swamps), lacustarine (lakes), riverine (along rivers and streams), and palustarine (‘marshy’ – marshes, swamps and bogs) based on their hydrological, ecological and geological characteristics (devised by Cowardin *et al.*, 1979). However, Ramsar Convention on Wetlands, which is an internationaltreaty signed in 1971 for the conservation and wise use of wetlands and their resources, defines wetlands (Article 1.1) as “areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which atlow tide does not exceed six metres”. Overall, 1052 sites in Europe; 289 sites in Asia; 359 sites in Africa; 175 sites in South America; 211 sites in North America; and 79 sites in Oceania region have been identified as Ramsar sites or wetlands of International importance (Ramsar Secretariat, 2013).

As per the Ramsar Convention definition most of the natural water bodies (such as rivers, lakes, coastal lagoons, mangrooves, peat land, coral reefs) and man made wetlands (such as ponds, farm ponds, irrigated fields, sacred groves, salt pans, reservoirs, gravel pits, sewage farms and canals) in India constitute the wetland ecosystem. Only 26 of these numerous wetlands have been designated as Ramsar Sites (Ramsar, 2013). However, many other wetlands which perform potentially valuable functions are continued to be ignored in the policy process. As a result many freshwater wetlands ecosystems are threatened and many

are already degraded and lost due to urbanization, population growth, and increased economic activities (Central Pollution Control Board, 2008).

1.1Wetland Status of India

National Wetland Atlas 2011, prepared by SAC, is the latest inventory on Indian wetlands. Entire Country was considered for assessment and a total of 201,503 wetlands were identified. India has about 757.06 thousand wetlands with a total wetland area4 of 15.3 m ha, accounting for nearly 4.7% of the total geographical area of the country. Out of this, area under inland wetlands accounts for 69%, coastal wetlands 27%, and other wetlands (smaller than 2.25 ha) 4% (SAC, 2011). In terms of average area under each type of wetland 5 natural coastal wetlands have the largest area (Fig.1).

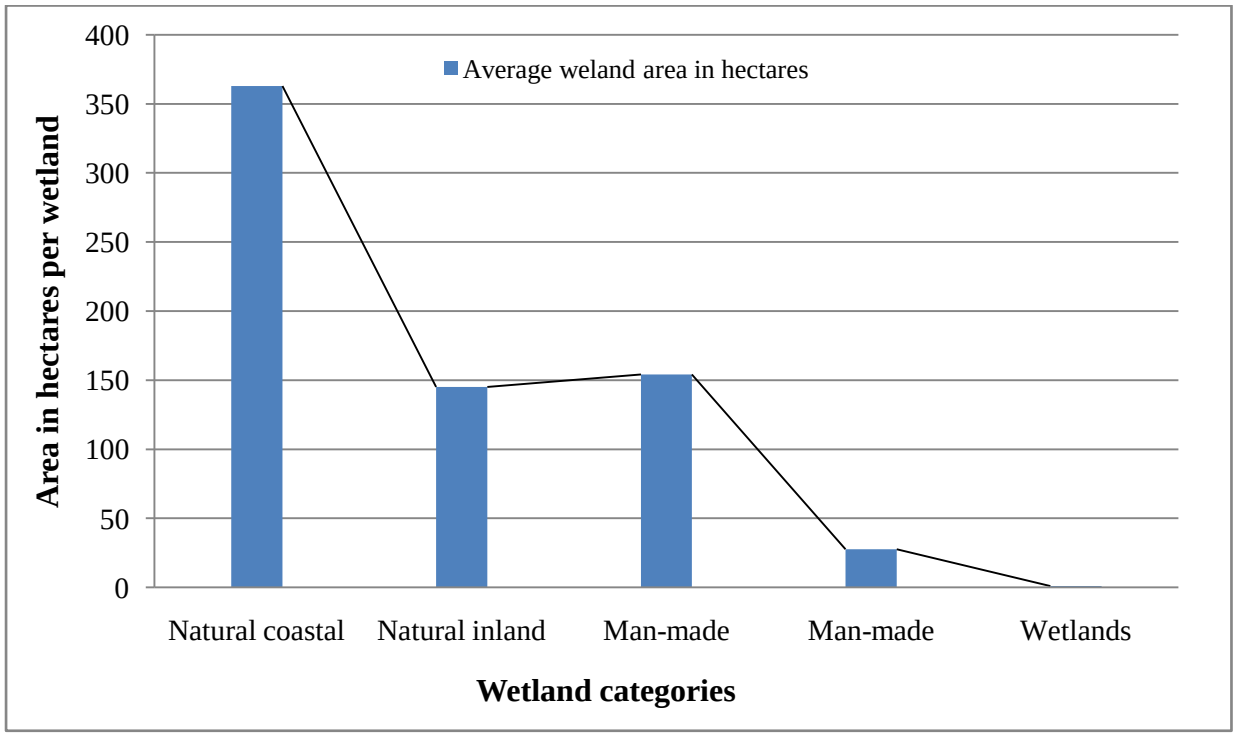


Figure 1: Average area under different wetlands, India.

1.2 Wetland status of Gujarat

Gujarat has the highest proportion (22.8%) of the total wetland area in the country. The extent of watery-lands in Gujarat is about 34,350 sq. km (17.6% of the state's geographical area and 22.9 % of the national wetlands). About one fourth of the India's wetlands are in Gujarat which includes Jheels (lakes), Talav (ponds), dams, seasonal waterbodies, paddy fields, streams, marsh lands, coastline, mangrooves, coral reefs, estuaries

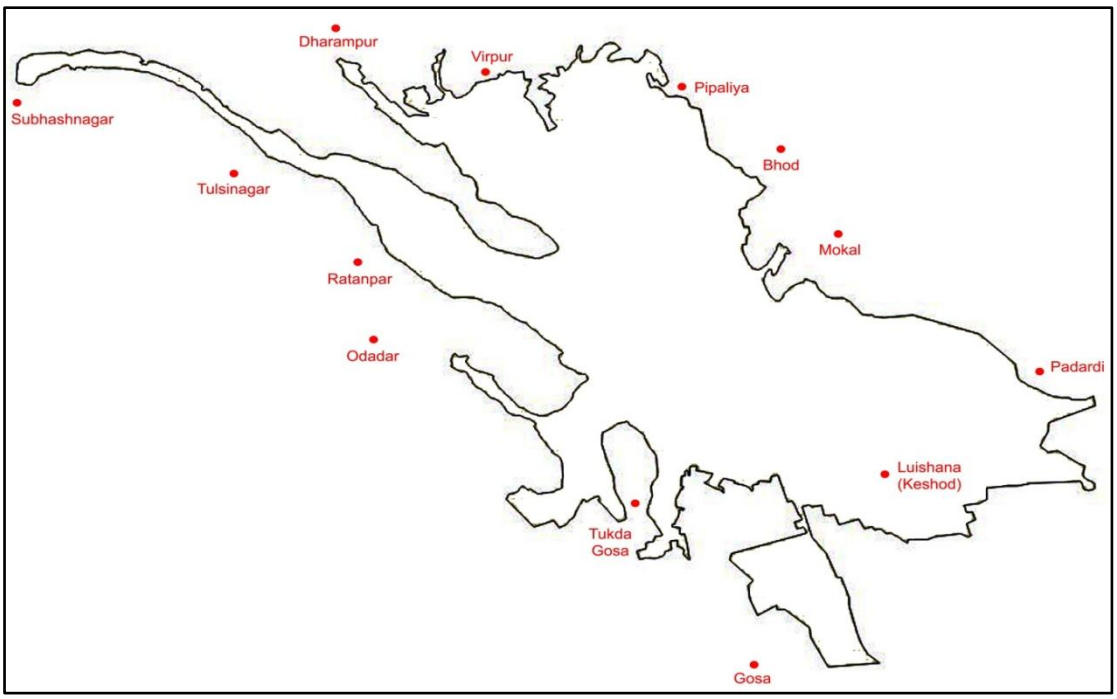
and large stretches of mudflats etc. contribute significantly to enrich habitat diversity, resulting in rich wetland biota.

1.3. Study Area

1.3.1 Mokarsagar wetland Complex

Mokarsagar Wetland Complex, located in the Porbandar district of Gujarat state is spread over around 129 square km. It lies between 21°38'49.17"N and 69°35'25.95"N to 21°29'51.11"N and 69°47'21.19"N.Mokarsagar is a name given to group of several wetlands situated in around villages like Kuchhadi, Zavar, Chhaya, Odedar, Ratanpar, Vanana, Ranghavav, Bhorasa, Dharampur, Gosa, Narvai, Bhad, Lushala, Navagam, Tukda, Mokar, Pipliya. Mokarsagar Wetland Complex (previously known as Gosabara) is the name given to the group of wetlands that includes Medha creek, Kuchhadi, Subhashnagar, Zavar, Kurly I, Kurly II, Vanana, Dharampur, Gosabara, Bhadarbara, Mokarsagar, Bardasagar and Amipur of Porbandar district of Gujarat (Map 1).

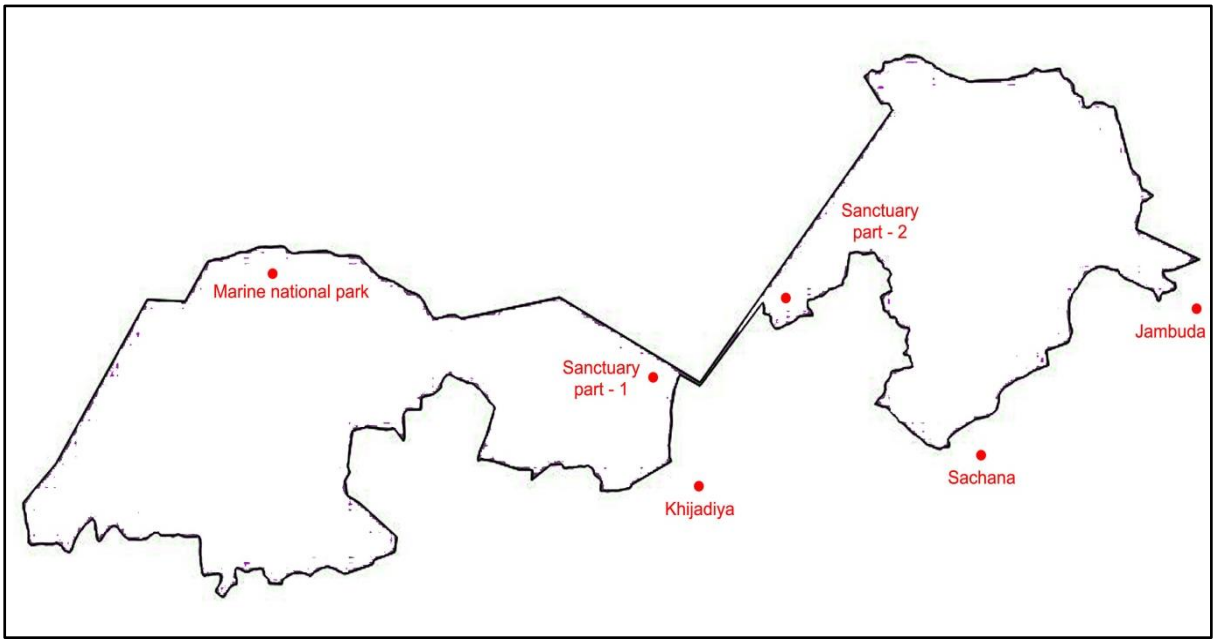
The wetland is formed by Karli Recharge Reservoir and Karli Tidal Regulator. There is a combination of Estuary and fresh water habitat. The wetland is dominated by sedges and other hydrophytic vegetation. It is a lifeline for the community as well as the wetland dependent biodiversity including both the flora (mangroove, macroalgae, macrophytes) and fauna (birds, reptiles, insects and mammals).



Map 1: Mokarsagar wetland map showing all surrounding villages

1.3.2 Khijadiya Wetland

Khijadiya wetland includes Khijadiya Bird Sanctuary as well as the part of Marine National Park. It lies between 22°30'12.96"N and 70°05'41.20"N to 22°31'38.17"N and 70°11'57.74"N. It is known as safe haven for birdslocated in Jamnagar district of Gujarat, India. The wetland is unique having both fresh water lakes, salt and freshwater marshlands. It is spread over an area of 19 square kilometer. Over the years with fresh water of the rain and river on one side and salt water of the sea on the other side, a unique area was formed here.On the other side of the bund large creeks flowing from the Gulf of Kutch are located. These creeks supports mangrooves vegetation mainly of *Avicennia marina* and other marine vegetation while on land side of the sanctuary inland vegetation like *Acacia nilotica, Salvadora persica* and *Prosopis juliflora* are found profusely.The sanctuary is located at the watershed of Ruparel and Kalindri River at the North East coastal region of Jamnagar district in the Gulf of Kutch (Map 2).



Map 2: Khijadiya Sanctuary map showing all surrounding villages

2. OBJECTIVES

1. Conduct a detailed desk study on the existing information, based on all possible sources of information, on the ecological characters and floral biodiversity elements at the two sites.
2. Detailed methodology and plan for each of the element.
3. Conduct detailed ecological assessment surveys (including diversity and population studies) on the two wetlands, over key seasons, including the following, but not limited to:

- All plants- diversity and population, including all plant forms

4. Assess the current threats to the above ecological elements assessed, on the two wetlands.
5. Identify the economically important species at the two wetlands, based on current and potential use of these species by the local community.
6. Identify threatened species, and other species of conservation significance.
7. Identify invasive species of the wetlands, and conduct detailed populations studies of the most significant species.
8. To the extent possible, document species names in English as well as in local language
9. Present a detailed ecological analysis of the key species interactions and ecological significance in the wetlands.

3. METHODOLOGY

3.1 ECOLOGICAL ASSESSMENT

3.1.1 DIVERSITY SURVEY

The diversity study has been carried out from October 2015 to April 2016 to monitor the change in the vegetation over a period of time. The GIS map has been prepared before starting the survey. Based on the GIS mapping the wetland habitat was divided into sixsub-habitats (Fig. 3&4).

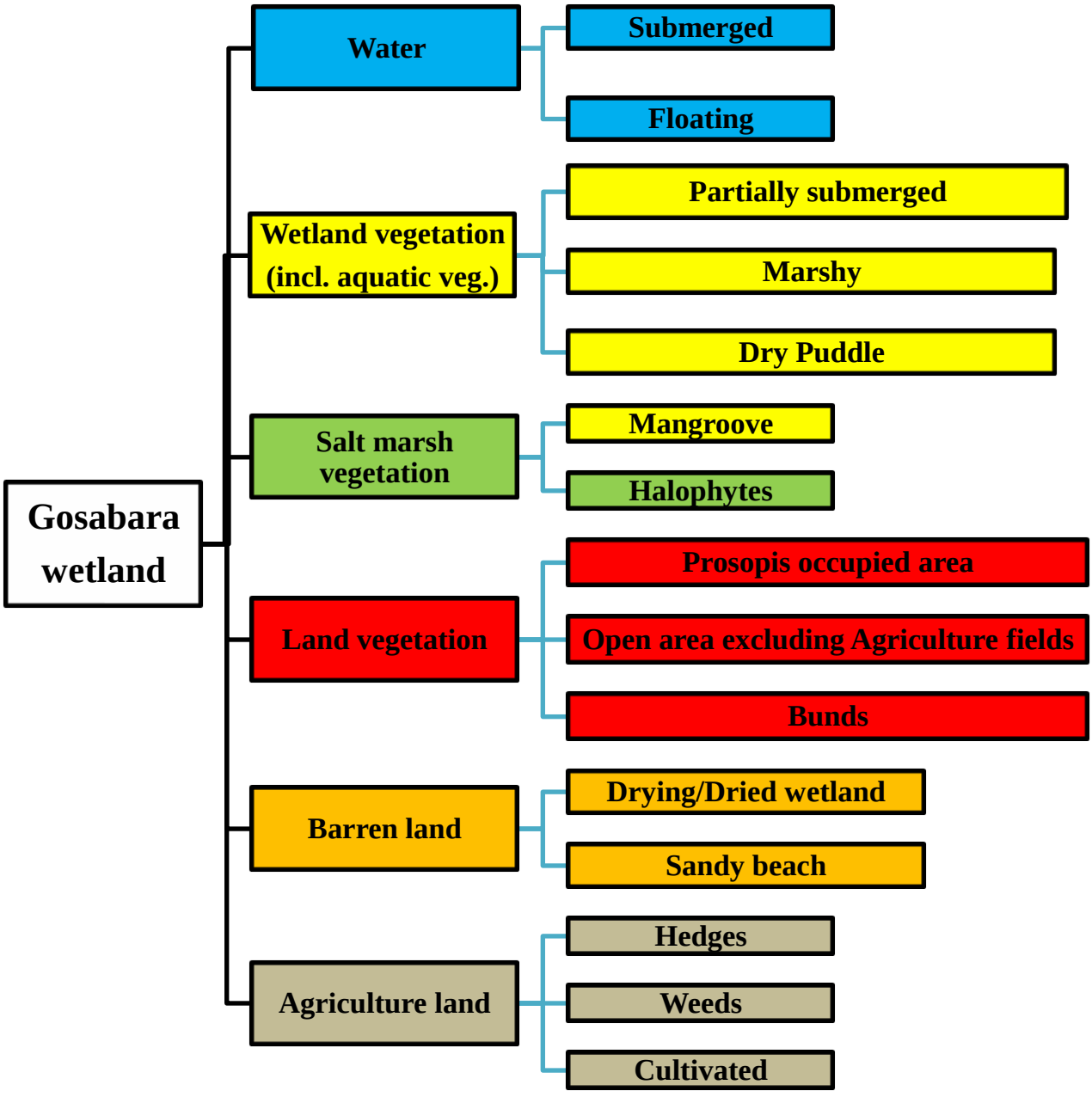


Figure 2: Habitat Classification of Gosabara

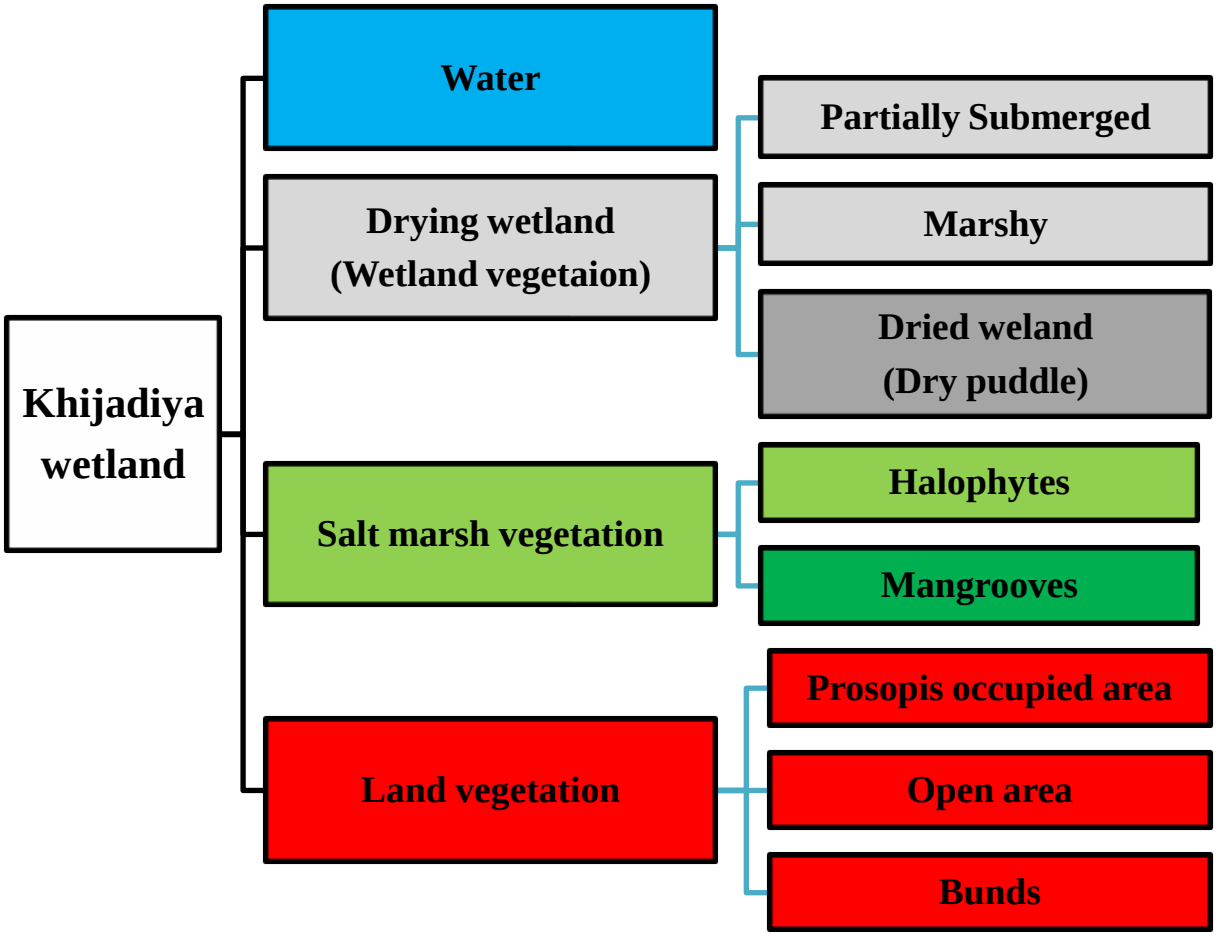


Figure 3: Habitat Classification of Khijadiya

The plants collected from various habitats were identified in the lab with the help of floral keys (Bole and Pathak, 1988; Cook, 1996; Cooke, 1958; Santapau, 1962; Shah 1978).The checklist of collected plantwas prepared according to their habitat and the information on their family and origin was also added to it.

3.1.2 PHYTOSOCIOLOGY

Phytosociological analysis was carried out to understand the floristic and vegetation pattern of the wetlands. The phytosociological database was created for both the wetlands and the basic structural parameters were computed such as relative frequency, relative dominance and relative density. Utilizing theses parameters, the importamce value index (IVI) was calculated for all the species. The tress having basal area more than 15 has been considred for IVI analysis.

The sample plot of 10 × 10 m^2 for trees, 5 × 5 m^2 for shrubs and tree regeneration, and and 1 × 1 $m^2$for herbs were taken in their respective zones (Vegetation type).

$$\text{Frequency} = \frac{\text{No.of Quadates in which species occured}}{\text{Total Number of quadrates studied}} \times 100$$

$$\text{Abundance} = \frac{\text{Total no.of Individuals of the species in which species occured}}{\text{No.of quadrates in which species occured}}$$

$$\text{Density} = \frac{\text{Total No.of individuals of a species in all quadrates}}{\text{Total no. of quadrates studied}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Sum of frequencies of all the species}} \times 100$$

$$\text{Relative Density} = \frac{\text{No.of individuals of a species in all quadrates}}{\text{No. of individual of all species in all quadrates}} \times 100$$

$$\text{Relative Dominance} = \frac{\text{Total stand basal cover of the species}}{\text{Total stand basal cover of all the species}} \times 100$$

Importance Value Index = Relative frequency + Relative density + Relative dominance

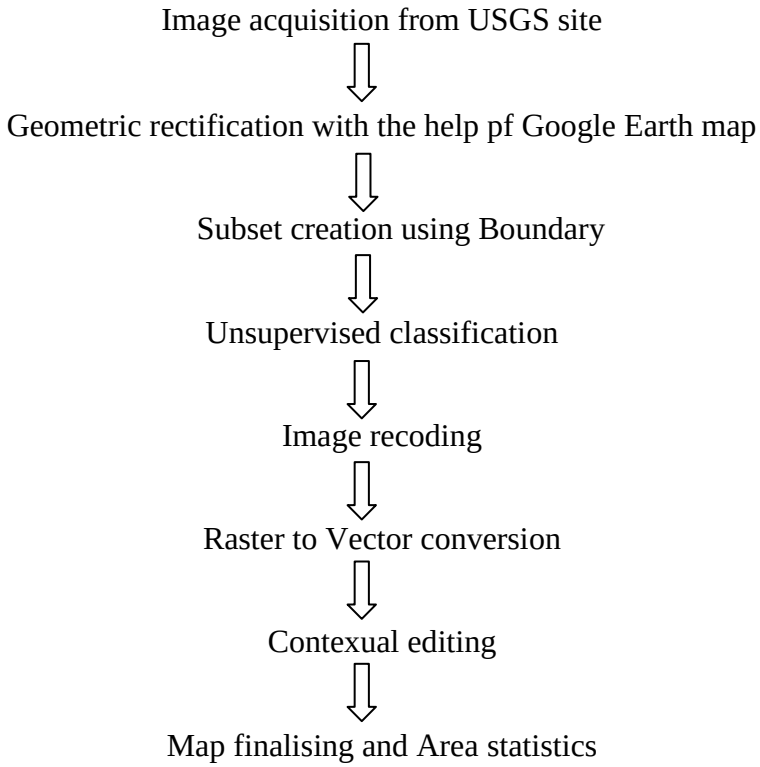
$$\text{Simpson's Index (D)} = \frac{\sum n(n-1)}{N(N-1)}$$

n = the total number of individuals of the species;

N = the total number of individuals of all species

3.1.3 GIS MAPPING

GIS mapping has been done to calculate the area occupied by various habitats and vegetation. The methodology adopted for GIS mapping was as follows:



3.1.4 BIOCHEMICAL PARAMETERS OF SOIL

The soil samples have been collected from various sites to check the quality of soil and its impact on vegetation diversity and agriculture.For quality analysis of soilparameters like total Nitrogen/Organic Carbon, Phosphorous, Potassium, pH and Conductivity has been taken in to consideration. A total of eight samples were collected for the analysis from various sites, of which five were from Gosabara and three from Khijadiya. The analysis has been carried out by the Gujarat State Fertilizer and Chemical Limited, Vadodara, Gujarat.

3.1.5 BIOCHEMICAL PARAMETERS OF WATER

For water analysis samplinghas been done from diverse sitesto analyse the water quality and the vegetation pattern of the area. The biochemical parameters like pH, Conductivity, Dissolved Oxygen (DO), Total Dissolved Solids (TDS), Nitrite and Nitrate content, Phytoplakton diversity and its density, Chlorophyll and Carotenoids has been taken in to consideration. Five litres of water sample has been collected in morning hours from

various sites. The sample analysis has been carried out by the Fisheries Research centre of Junagadh Agriculture University.

3.2THREAT ASSESMENT

Threat assessment to the biodiversity and ecological parameters has been done during the survey and by carrying out the interview with the local peoples.

3.3ECONOMICALLY IMPORTANT SPECIES

The economically important species has been identified by interviewing local communities and the uses of various species have been noted down.Based on the information given by the people TIV value (Total Importance Value) has been calculated.

Importance value has been derived based on primary uses. The potential uses considered during the study are forage, Food/nutrition value, Medicine, Fibre, Fodder, Fuelwood, Timber, Toothbrush, Oil and Gum value. A range of 0-10 points to economic value for each use was assigned and the total importance value (TIV) (potential importance of the plant to the local economy) has thus been calculated as below:

$$\text{TIV \%} = \frac{U1 + U2 \ldots Un}{\text{Number of uses} \times \text{maximum value}} \times 100$$

Where TIV % is the total importance value and U is the importance value for each particular use (e.g. timber, fuelwood, fodder, etc.)

3.4 THREATENED SPECIES AND THEIR CONSERVATION SIGNIFICANCE

The IUCN status of all the collected species has been analysed as per the IUCN Red List version 2.3 and 3.1. (www.iucnredlist.org)

3.5 DOCUMENTATION OF LOCAL AND ENGLISH NAME

The information on local names of the species was gathered from local communities during the survey. The information on the English name of the plant was taken from available resources (www.iucnredlist.org, www.cabi.org, www.iucngisd.org).

4. RESULTS

4.1 ECOLOGICAL ASSESSMENT

4.1.1 DIVERSITY SURVEY

4.1.1.1 Gosabara

Gosabara wetland, complex comprises of 157 taxa of which 2 are pteridophytes and 155 are angiosperms. Out of 155 species of Angiosperm; 121 are Dicots belonging to 102 genus and 35 are monocots belonging to 33 genus. According to their origin out of121 species of dicotyledons, 1 is endemic, 19 are exotic, and 10 are indigenous.Fabaceae and Asteraceae are the two dominant families among dicotyledons.Similarly out of the 35 monocots, 31 are indigenous, 2 are exotic and one is endemic, of which Poaceae is the dominant family (Fig. 4).

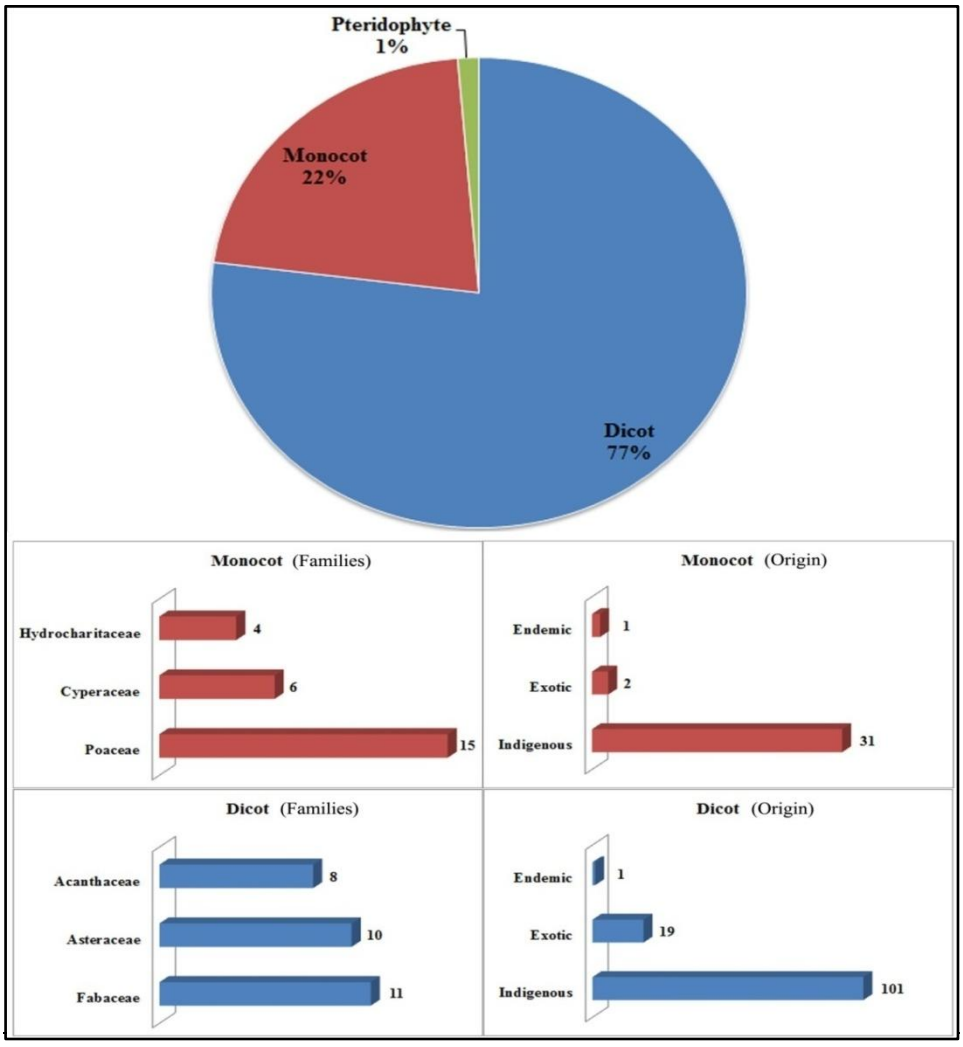


Figure 4: Graph showing species diversity at Gosabara wetland complex

Out of 157 species, recorded from Gosabara wetland complex; 43 are of aquatic subhabitat which is further classified into four micro habitats. Five species are of submereged habitat with Hydrocharitaceae as dominant family. Four species were partially submerged, six were floating hydrophytes, 16 were of marshy habitat and 13 were dry puddle species.The salt marsh vegetation is represented by 7 species of salt loving or salt tolerant plants on saline gorund and the area under the influence of tides. Land vegetation includes plants on the open land area of wetland which represents 71 species where *Prosopis* is the main dominant species which is an invasive plant. Agriculture land vegetation includes the plants growing on the agriculture hedges to the surrounding and adjacent wetland area represented by 18 species.Based on their habit out of 157 species, 104 were herbs, seven climbing herbs, three twining herbs, one creeping herb, twenty shrubs, two twining shrubs, four climbing shrubs, six under shrubs, twenty shrubs and ten trees(Table 1).

Table 1: Floristic Diversity of Gosabara

SN	Botanical name	Family	Habit	Phenology	Origin
Water					
Submerged aquatic plants					
1.	*Hydrilla verticillata* (L. f.) Royle	Hydrocharitaceae	Aquatic herb	Oct-Jan	Indigenous
2.	*Najas marina* L.	Hydrocharitaceae	Aquatic herb	Jan-Apr	Indigenous
3.	*Ottelia alismoides* (L.) Pers.	Hydrocharitaceae	Aquatic herb	Oct-Mar	Indigenous
4.	*Stuckenia pectinata* (L.) Boerner	Potamogetonaceae	Aquatic herb	Aug-Oct	Indigenous
5.	*Vallisneria natans* (Lour.) H. Hara	Hydrocharitaceae	Aquatic herb	Oct-Feb	Indigenous
Floating aquatic plants					
6.	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	Aquatic herb	Oct-Dec	Exotic
7.	*Ipomoea aquatica* Forssk.	Convolvulaceae	Twining herb	Oct-Dec	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
8.	*Lemna gibba* L.	Lemnaceea	Aquatic herb	Sep-Dec	Indigenous
9.	*Limnophyton obtusifolium* (L.) Miq.	Alismataceae	Aquatic herb	Sep-Feb	Indigenous
10.	*Nymphaea pubescens* Willd.	Nymphaeaceae	Aquatic herb	Oct-Dec	Indigenous
11.	*Nymphaea rubra* Roxb. ex Andrews	Nymphaeaceae	Aquatic herb	Oct-Dec	Indigenous
Wetland vegetation (incl. aquatic vegetation)					
Partially submerged aquatic plants					
12.	*Bolboschoenus maritimus* ssp. *affinis* (Roth.) T. Koyama	Cyperaceae	Annual	Sep-Dec	Indigenous
13.	*Fimbristylis ferruginea* (L.) Vahl.	Cyperaceae	Perennial	Sep-Nov	Indigenous
14.	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae	Perennial	Oct-Feb	Indigenous
15.	*Schoenoplectus subulatus* (Vahl) Lye	Cyperaceae	Perennial	Sep-Jan	Indigenous
Wetland or marshy plants					
16.	*Ammannia baccifera* L. var. *baccifera*	Lythraceae	Marshy herb	Dec-Feb	Indigenous
17.	*Bacopa monnieri* (L.) Pennell	Plantaginaceae	Herb	Jan-Mar	Indigenous
18.	*Ceratopteris thalictroides* (L.) Brongn.	Pteridaceae	Herb	-	Indigenous
19.	*Eclipta prostrata* (L.) L. var.*Prostrate*	Asteraceae	Herb	Aug-Jan	Indigenous
20.	*Echinochloa colona* (L.) Link	Poaceae	Annual	Aug-Feb	Indigenous
21.	*Eleocharis geniculata* (L.) Roem. & Schult.	Cyperaceae	Annual	Aug-Feb	Indigenous
22.	*Hygrophila schulli* (Buch.-Ham.) M. R. Almeida & S. M. Almeida	Acanthaceae	Herb	Sep-Mar	Indigenous
23.	*Marsilea quadrifolia* L.	Marsileaceae	Herb	-	Indigenous
24.	*Paspalidium geminatum* (Forssk.) Stapf	Poaceae	Perennial	Aug-Nov	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
25.	*Paspalum vaginatum* Sw.	Poaceae	Annual	Jul-Nov	Indigenous
26.	*Oxystelma esculentum* (L. f.) Sm.	Asclepiadaceae	Twining herb	Aug-Oct	Indigenous
27.	*Typha angustifolia* L.	Typhaceae	Herb	Throughout	Indigenous
Dry puddle vegetation					
28.	*Chrozophora plicata* (Vahl) A. Juss. ex Spreng.	Euphorbiaceae	Herb	July-Oct	Indigenous
29.	*Chrozophora rottleri* (Geiseler) A. Juss. ex Spreng.	Euphorbiaceae	Herb	July-Apr	Indigenous
30.	*Coldenia procumbens* L.	Boraginaceae	Herb	Throughout	Indigenous
31.	*Commelina benghalensis* L.	Commelinaceae	Herb	Aug-Jan	Indigenous
32.	*Dopatrium junceum* (Roxb.) Buch.-Ham. ex Benth.	Scrophulariaceae	Herb	Aug-Dec	Indigenous
33.	*Euphorbia prostrata* Aiton	Euphorbiaceae	Herb	Throughout	Exotic
34.	*Glinus lotoides* L.	Aizoaceae	Herb	Throughout	Indigenous
35.	*Grangea maderaspatana* (L.) Poir.	Asteraceae	Herb	Dec-Apr	Indigenous
36.	*Heliotropium curassavicum* L.	Boraginaceae	Herb	Throughout	Exotic
37.	*Heliotropium supinum* L.	Boraginaceae	Herb	Aug-Apr	Indigenous
38.	*Phyla nodiflora* (L.) Greene	Verbenaceae	Herb	Throughout	Indigenous
39.	*Polygonum plebeium* R. Br. var.*plebeium*	Polygonaceae	Herb	Sep-May	Indigenous
40.	*Portulaca quadrifida* L.	Portulacaceae	Herb	Throughout	Indigenous
41.	*Merremia emarginata* (Burm. f.) Hallier f.	Convolvulaceae	Creeping herb	Aug-Feb	Indigenous
42.	*Mollugo pentaphylla* L.	Aizoaceae	Herb	Jul-Dec	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
Mangrooves					
43.	*Avicennia marina* (Forssk.) Vierh.	Avicenniaceae	Tree	Feb-Jun	Indigenous
Salt marsh vegetation					
44.	*Aeluropus lagopoides* (L.) Trin. ex Thwaites	Poaceae	Perennial	Oct-Dec	Indigenous
45.	*Arthrocnemum indicum* (Willd.) Moq.	Chenopodiaceae	Herb	Oct-Dec	Indigenous
46.	*Atriplex stocksii* (Wight) Boiss.	Chenopodiaceae	Under shrub	Sep-Apr	Indigenous
47.	*Cressa cretica* L.	Convolvulaceae	Herb	Throughout	Indigenous
48.	*Salicornia brachiata* Roxb.	Chenopodiaceae	Herb	Nov-Feb	Indigenous
49.	*Suaeda fruticosa* Forssk. ex J. F. Gmelin	Chenopodiaceae	Under Shrub	Apr-Sep	Indigenous
50.	*Suaeda nudiflora* Moq.	Chenopodiaceae	Herb	Apr-Sep	Indigenous
Barren land					
Sandy beach					
51.	*Convolvulus microphyllus* Seiber ex Spreng.	Convolvulaceae	Herb	Aug-Oct	Indigenous
52.	*Cyperus arenarius* Retz.	Cyperaceae	Perennial	Jun-Dec	Indigenous
53.	*Halopyrum mucronatum* (L.) Stapf.	Poaceae	Perennial	Oct-Dec	Indigenous
54.	*Heliotropium bacciferum* Forssk.	Boraginaceae	Herb	Dec-Apr	Indigenous
55.	*Lotus garcinii* DC.	Fabaceae	Herb	Apr-Aug	Indigenous
56.	*Polycarpaea spicata* Wight & Arn.	Caryophyllaceae	Herb	Oct-Nov	Indigenous
57.	*Pulicaria angustifolia* DC.	Asteraceae	Herb	Feb-Aug	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
Land vegetation					
***Prosopis* occupied area**					
58.	*Acacia nilotica* ssp. *indica* (Benth.) Brenan	Mimosaceae	Tree	Jul-Oct	Indigenous
59.	*Prosopis juliflora* (Sw.) DC.	Mimosaceae	Tree	Aug-May	Exotic
60.	*Leucaena leucocephala* (Lam.) de Wit.	Mimosaceae	Tree	May-Feb	Exotic
61.	*Wattakaka volubilis* (L. f.) Stapf	Asclepiadaceae	Twining shrub	Apr-Feb	Indigenous
62.	*Tinospora cordifolia* (Willd.) Miers ex Hook. f. & Thomson	Menispermaceae	Climbing shrub	Jan-Aug	Indigenous
63.	*Senna auriculata* (L.) Roxb.	Caesalpiniaceae	Under Shrub	Jan-Jul	Indigenous
64.	*Salvadora persica* var. *indica* (Wight) T. A. Rao & Chakraborti	Salvadoraceae	Tree	Nov-Feb	Indigenous
Bunds					
65.	*Abutilon indicum* (L.) Sweet ssp. *indicum*	Malvaceae	Shrub	Throughout	Indigenous
66.	*Abutilon ramosum* (Cav.) Guill. & Perr.	Malvaceae	Shrub	Sep-Oct	Indigenous
67.	*Achyranthes aspera* L. var. *Aspera*	Amaranthaceae	Herb	Throughout	Indigenous
68.	*Aristolochia bracteolata* Lam.	Aristolochiaceae	Herb	Jul-Dec	Indigenous
69.	*Azadirachta indica* A. Juss.	Meliaceae	Tree	Dec-May	Indigenous
70.	*Barleria prionitis* L. ssp. *Prionitis*	Acanthaceae	Herb	Sep-Mar	Indigenous
71.	*Bergia suffruticosa* (Delile) Fenzl	Elatinaceae	Under shrub	Throughout	Indigenous
72.	*Blepharis integrifolia* (L. f.) E. Mey. & Drege ex Schinz	Acanthaceae	Herb	Oct-Mar	Indigenous
73.	*Boerhavia chinensis* (L.) Rottb.	Nyctaginaceae	Herb	Feb-Dec	Indigenous
74.	*Calotropis gigantea* (L.) R. Br.	Asclepiadaceae	Shrub	Throughout	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
75.	*Calotropis procera* (Aiton) R. Br.	Asclepiadaceae	Shrub	Throughout	Indigenous
76.	*Capparis decidua* (Forssk.) Edgew.	Capparaceae	Shrub	Feb-Sep	Indigenous
77.	*Cardiospermum halicacabum* L.	Sapindaceae	Climbing herb	Jul-Feb	Indigenous
78.	*Clerodendron serratum* (L.) Moon	Verbenaceae	Shrub	Jun-Dec	Indigenous
79.	*Clitoria ternetea* var. *ternetea* f.*Albiflora*	Fabaceae	Climbing herb	Throughout	Exotic
80.	*Clitoria ternetea* var. *ternetea* f.*Ternetea*	Fabaceae	Climbing herb	Throughout	Exotic
81.	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae	Climbing shrub	Nov-Apr	Indigenous
82.	*Corchorus aestuans* L.	Tiliaceae	Herb	Aug-Dec	Exotic
83.	*Corchorus olitorius* L.	Tiliaceae	Herb	Aug-Dec	Indigenous
84.	*Corchorus tridens* L.	Tiliaceae	Herb	Aug-Dec	Indigenous
85.	*Corchorus trilocularis* L.	Tiliaceae	Herb	Jul-Mar	Indigenous
86.	*Ctenolepis cerasiformis* (Stocks) Hook. f.	Cucurbitaceae	Climbing herb	Aug-Oct	Indigenous
87.	*Cucumis maderaspatanus* L.	Cucurbitaceae	Climbing herb	Jul-Nov	Indigenous
88.	*Cucumis prophetarum* L.	Cucurbitaceae	Climbing herb	Jul-Oct	Indigenous
89.	*Cynodon dactylon* (L.) Pers.	Poaceae	Perennial	Throughout	Indigenous
90.	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Annual	Throughout	Indigenous
91.	*Datura metel* L.	Solanaceae	Shrub	Throughout	Indigenous
92.	*Dinebra retroflexa* (Vahl) Panz.	Poaceae	Annual	Aug-Feb	Indigenous
93.	*Launaea procumbens* (Roxb.) Ramayya & Rajagopal	Asteraceae	Herb	Throughout	Indigenous
94.	*Maerua oblongifolia* (Forssk.) A. Rich.	Capparaceae	Climbing shrub	Oct-Feb	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
95.	*Passiflora foetida* L. var. *foetida*	Passifloraceae	Climbing shrub	Aug-Dec	Exotic
96.	*Pavonia ceratocarpa* Masters	Malvaceae	Herb	Aug-Oct	Indigenous
97.	*Pentatropis spiralis* (Forssk.)Decne.	Asclepiadaceae	Twining herb	Aug-Dec	Indigenous
98.	*Pergularia daemia* (Forssk.) Chiov.	Asclepiadaceae	Twining shrub	Oct-Mar	Indigenous
99.	*Peristrophe bicalyculata* (Retz.) Nees	Acanthaceae	Herb	Oct-Apr	Indigenous
100.	*Physalis minima* L.	Solanaceae	Herb	Jul-Jan	Indigenous
101.	*Rungia elegans* Dalzell & A. Gibson	Acanthaceae	Herb	Sep-Mar	Endemic
102.	*Rungia repens* (L.) Nees	Acanthaceae	Herb	Aug-Jan	Indigenous
103.	*Senna occidentalis* (L.) Link.	Caesalpiniaceae	Under Shrub	Throughout	Exotic
104.	*Setaria pumila* (Poir.) Roem. & Schult.	Poaceae	Annual	Jul-Nov	Indigenous
105.	*Sida mysorensis* Wight & Arn.	Malvaceae	Herb	Aug-Dec	Exotic
Open lands					
106.	*Nothosaerva brachiata* (L.) Wight	Amaranthaceae	Herb	Sep-May	Indigenous
107.	*Ocimum americanum* L.	Lamiaceae	Herb	Throughout	Indigenous
108.	*Parthenium hysterophorus* L.	Asteraceae	Herb	Sep-Mar	Exotic
109.	*Dyerophytum indicum* (Gibson ex Wight) Kuntze	Plumbaginaceae	Shrub	Oct-Feb	Indigenous
110.	*Echinops echinatus* Roxb.	Asteraceae	Herb	Sep-Jan	Indigenous
111.	*Elytraria acaulis* (L. f.) Lindau	Acanthaceae	Herb	Jul-Dec	Indigenous
112.	*Enicostema axillare* (Lam.) A. Raynal ssp. *axillare*	Gentianaceae	Herb	Jul-Nov	Indigenous
113.	*Eragrostis ciliaris* (L.) R. Br.	Poaceae	Annual	Oct-Jan	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
114.	*Euphorbia neriifolia* L.	Euphorbiaceae	Shrub	Nov-Apr	Indigenous
115.	*Gossypium stocksii* Mast.	Malvaceae	Shrub	Oct-Dec	Exotic
116.	*Grewia tenax* (Forssk.) Fiori	Tiliaceae	Shrub	Apr-Sep	Indigenous
117.	*Justicia procumbens* L.	Acanthaceae	Herb	Jun-Dec	Indigenous
118.	*Tridax procumbens* L.	Asteraceae	Herb	Throughout	Exotic
119.	*Verbascum chinense* (L.) Santapau	Scrophulariaceae	Herb	Throughout	Indigenous
120.	*Vernonia cinerea* (L.) Less.	Asteraceae	Herb	Throughout	Indigenous
121.	*Commiphora wightii* (Arn.) Bhandari	Burseraceae	Shrub	Jan-May	Indigenous
122.	*Celosia argentea* L.	Amaranthaceae	Herb	Jul-Dec	Indigenous
123.	*Cenchrus ciliaris* L.	Poaceae	Annual	Jul-Jan	Indigenous
124.	*Chloris barbata* Sw.	Poaceae	Perennial	Jul-Apr	Indigenous
125.	*Pluchea lanceolata* (DC.) C.B.Clarke	Asteraceae	Herb	Jan-Apr	Indigenous
126.	*Tamarix indica* Willd.	Tamaricaceae	Tree	Aug-Mar	Indigenous
127.	*Solanum virginianum* L.	Solanaceae	Herb	Throughout	Indigenous
128.	*Sporobolus virginicus* (L.) Kunth	Poaceae	Perennial	Aug-Dec	Indigenous
129.	*Hyphaene dichotomoma* (Wight ex Graham) Furtado	Arecaceae	Tree	Jul-Sep	Endemic
130.	*Indigofera cordifolia* B. Heyne ex Roth	Fabaceae	Herb	Throughout	Indigenous
131.	*Indigofera oblongifolia* Forssk.	Fabaceae	Herb	Sep-Oct	Indigenous
132.	*Stemodia viscosa* Roxb.	Scrophulariaceae	Herb	Oct-May	Indigenous
133.	*Ziziphus nummularia* (Burm. f.) Wight. & Arn. var. *nummularia*	Rhamnaceae	Shrub	Jul-Jan	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
134.	*Alhagi maurorum* Medik.	Fabaceae	Herb	Mar-Apr	Indigenous
135.	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	Herb	Throughout	Indigenous
136.	*Alysicarpus longifolius* (Rottler ex Spreng.) Wight & Arn.	Fabaceae	Herb	Sep-Mar	Indigenous
137.	*Argemone mexicana* L.	Papaveraceae	Herb	Throughout	Exotic
138.	*Aristida adscensionis* L.	Poaceae	Annual	Aug-Jan	Indigenous
139.	*Xanthium indicum* J. Koenig ex Roxb.	Asteraceae	Herb	Throughout	Indigenous
Agriculture land					
Hedges					
140.	*Aloe vera* (L.) Burm. f.	Liliaceae	Herb	Dec-May	Exotic
141.	*Cordia sinensis* Lam.	Boraginaceae	Tree	Apr-Oct	Indigenous
142.	*Cadaba fruticosa* (L.) Druce	Capparaceae	Shrub	Dec-Apr	Indigenous
143.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Climbing herb	Throughout	Indigenous
144.	*Opuntia elatior* L.	Cactaceae	Shrub	Dec-May	Exotic
145.	*Parkinsonia aculeata* L.	Caesalpiniaceae	Shrub	Nov-Mar	Exotic
146.	*Ziziphus mauritiana* Lam. var.*mauritiana*	Rhamnaceae	Shrub	Sep-Feb	Indigenous
147.	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	Tree	Jan-Jul	Exotic
148.	*Lantana camara* ssp. *aculeata* (L.) R. W. Sanders	Verbenaceae	Shrub	Throughout	Exotic
149.	*Taverniera cuneifolia* (Roth) Arn.	Fabaceae	Undershrub	Aug-Nov	Indigenous
Weeds					
150.	*Asphodelus tenuifolius* Cav.	Asphodelaceae	Herb	Dec-Mar	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
151.	*Cyperus esculentus* L.	Cyperaceae	Annual	Jun-Oct	Indigenous
152.	*Corchorus depressus* (L.) Vicary	Tiliaceae	Herb	Sep-Oct	Indigenous
153.	*Chenopodium album* L.	Chenopodiaceae	Herb	Nov-Apr	Indigenous
154.	*Euphorbia perfoliata* Scheutz	Euphorbiaceae	Herb	Sep-Nov	Indigenous
155.	*Medicago sativa* L.	Fabaceae	Herb	Throughout	Exotic
156.	*Sesbania bispinosa* (Jacq.) W.Wight	Fabaceae	Shrub	Jul-Mar	Indigenous
157.	*Sesbania sesban* (L.) Merr.	Fabaceae	Shrub	Aug-Dec	Indigenous

There are 14 species which are cultivated in the interzonal wetland area of Gosabara that includes 7 dicots and 7 monocots(Table 2). The cultivated species have been not incorporated in the list of wild species diversity (Table 2). These cultivated species covers majior part of Agriculture habitat.

Table 2: Agricultural crops of Gosabara

SN	Crops	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
1.	*Pennissetum glaucum* (Bajro)	0	1	0	1	1	1	1
2.	*Daucus carota* (Carrot)	0	0	0	0	0	1	1
3.	*Ricinus communis* (Castor)	0	1	0	0	0	0	0
4.	*Cocos nucifera* (Coconut)	0	0	1	0	0	0	0
5.	*Gossypium herbaceum* (Cotton)	1	1	1	1	1	1	1
6.	*Coriander sativum*(Dhaniya)	1	1	0	1	1	1	1

SN	Crops	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
7.	*Medicago sativa* (Gadab)	0	0	0	0	0	1	1
8.	*Arachis hypogaea*(Ground nut)	1	1	1	1	1	1	1
9.	*Cuminum cyminum*(Jeeru)	1	1	1	1	1	1	1
10.	*Sorghum bicolour* (Juwar)	1	1	1	1	1	1	1
11.	*Raphanus sativus* (Muli)	0	0	0	0	0	1	1
12.	*Solanum lycopersicum*(Tomato)	0	0	0	0	0	1	1
13.	*Triticum aestivum* (Wheat)	0	0	0	0	0	0	1
14.	*Zea mays* (Maize)	0	0	0	0	0	0	1

4.1.1.2 Khijadiya

From Khijadiya Bird Sanctuary total 86 plant taxa were documented during current field assessment of which 85 are angiosperms and one was Pteridophyte. Out of 85 Angiosperm species69 were dicotsbelonging to 61 genus and 17 were monocots belonging to 17 genus. Out ofthe 69 dicots, 60 are of indigenous origin and 9 are exotic with Chenopodiaceae and Asteraceae as dominant family.Similarly out of 17 species ofmonocots, 15 are ofindigenous origin and 2 are exotic with poaceae as domiant family (Figure 5).

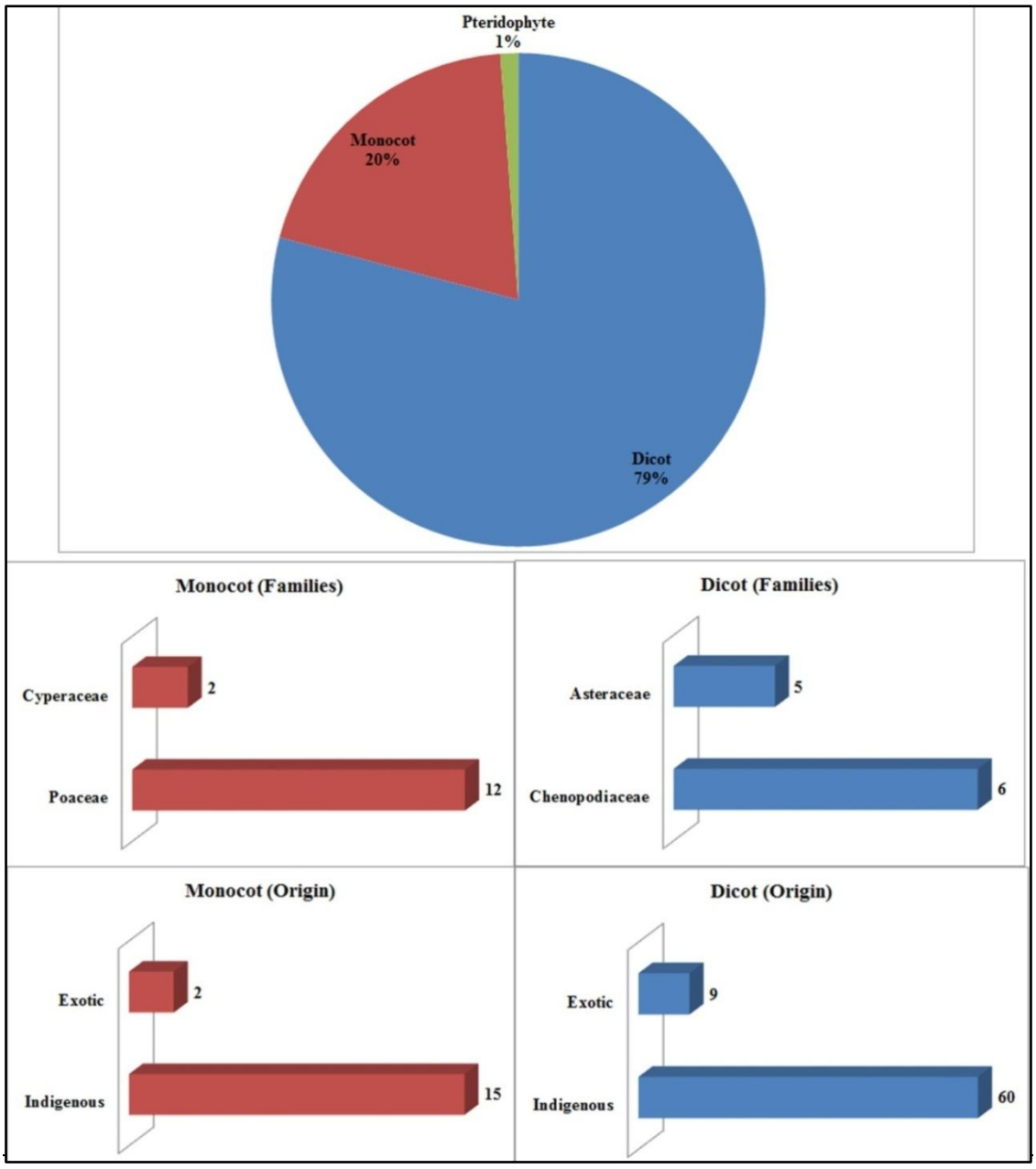


Figure 5: Graph showing species diversity at Khijadiya Sanctuary

Out of 86 recorded species, 21 are of aquatic sub habitat which is further classified in to four micro habitats. Three species were partially submerged, six were of marshy habitat and twelve were dry puddle of habitat. The salt marsh vegetation is represented by 15 species of salt tolerant plants on saline gorund and the area under the influence of tides. Land vegetation includes plants on the open land area of wetland which represents 50 species where the *Prosopis* is main invasive species in whole sanctuary area. Based on their habit, out of 86 speceis 51 were herbs, two climbing herbs, one creeping herb, one twining herb, two climbing shrub, three under shrub, twelve shrubs and eleven trees (Table 3).

Table 3: Floristic Diversity of Khijadiya

SN	Botanical name	Family	Habit	Phenology	Origin
Drying wetland					
Partially submerged aquatic plants					
1.	*Bolboschoenus maritimus* ssp. *affinis* (Roth.) T. Koyama	Cyperaceae	Annual	Sep-Dec	Indigenous
2.	*Phragmites karka* (Retz.) Trin. ex Steud.	Poaceae	Perennial	Oct-Feb	Indigenous
3.	*Schoenoplectus subulatus* (Vahl) Lye	Cyperaceae	Perennial	Sep-Jan	Indigenous
Wetland or marshy plants					
4.	*Ammannia baccifera* L. var. *Baccifera*	Lythraceae	Marshy herb	Dec-Feb	Indigenous
5.	*Echinochloa colona* (L.) Link	Poaceae	Annual	Aug-Feb	Indigenous
6.	*Marsilea quadrifolia* L.	Marsileaceae	Herb	Jan-Feb	Indigenous
7.	*Paspalidium geminatum* (Forssk.) Stapf	Poaceae	Perennial	Aug-Nov	Indigenous
8.	*Phyla nodiflora* (L.) Greene	Verbenaceae	Herb	Throughout	Indigenous
9.	*Polygonum plebeium* R. Br. var. *plebeium*	Polygonaceae	Herb	Sep-May	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
Dried wetland					
10.	*Chrozophora plicata* (Vahl) A. Juss. ex Spreng.	Euphorbiaceae	Herb	July-Oct	Indigenous
11.	*Chrozophora rottleri* (Geiseler) A. Juss. ex Spreng.	Euphorbiaceae	Herb	July-Apr	Indigenous
12.	*Coldenia procumbens* L.	Boraginaceae	Herb	Throughout	Indigenous
13.	*Corchorus depressus* (L.) Vicary	Tiliaceae	Herb	Sep-Oct	Indigenous
14.	*Dopatrium junceum* (Roxb.) Buch.-Ham. ex Benth.	Scrophulariaceae	Herb	Aug-Dec	Indigenous
15.	*Eclipta prostrata* (L.) L. var. *Prostrate*	Asteraceae	Herb	Aug-Jan	Indigenous
16.	*Glinus lotoides* L.	Aizoaceae	Herb	Throughout	Indigenous
17.	*Grangea maderaspatana* (L.) Poir.	Asteraceae	Herb	Dec-Apr	Indigenous
18.	*Heliotropium curassavicum* L.	Boraginaceae	Herb	Throughout	Exotic
19.	*Heliotropium supinum* L.	Boraginaceae	Herb	Aug-Apr	Indigenous
20.	*Merremia emarginata* (Burm. f.) Hallier f.	Convolvulaceae	Creeping herb	Aug-Feb	Indigenous
21.	*Mollugo pentaphylla* L.	Aizoaceae	Herb	Jul-Dec	Indigenous
Mangroove					
22.	*Avicennia marina* (Forssk.) Vierh.	Avicenniaceae	Shrub	Feb-Jun	Indigenous
23.	*Ceriops tagal* (Perr.) C.B. Rob.	Rhizophoraceae	Small tree	Jul-Sep	Indigenous
24.	*Rhizophora mucronata* Lam.	Rhizophoraceae	Small tree	Aug-Dec	Indigenous
Salt marsh vegetation					
25.	*Aeluropus lagopoides* (L.) Trin. ex Thwaites	Poaceae	Perennial	Oct-Dec	Indigenous
26.	*Arthrocnemum indicum* (Willd.) Moq.	Chenopodiaceae	Herb	Oct-Dec	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
27.	*Atriplex stocksii* (Wight) Boiss.	Chenopodiaceae	Under shrub	Sep-Apr	Indigenous
28.	*Cressa cretica* L.	Convolvulaceae	Herb	Throughout	Indigenous
29.	*Juncus maritimus* Lam.	Juncaceae	Herb	Oct-Dec	Exotic
30.	*Polycarpaea spicata* Wight & Arn.	Caryophyllaceae	Herb	Oct-Nov	Indigenous
31.	*Salicornia brachiata* Roxb.	Chenopodiaceae	Herb	Nov-Feb	Indigenous
32.	*Salvadora persica* var. *indica* (Wight) T. A. Rao & Chakraborti	Salvadoraceae	Tree	Nov-Feb	Indigenous
33.	*Sesuvium portulacastrum* (L.) L.	Aizoaceae	Herb	Nov-Jan	Indigenous
34.	*Suaeda fruticosa*Forssk. ex J. F. Gmelin	Chenopodiaceae	Shrub	Apr-Sep	Indigenous
35.	*Suaeda nudiflora* Moq.	Chenopodiaceae	Herb	Apr-Sep	Indigenous
36.	*Tamarix stricta* Boiss.	Tamaricaceae	Shrub	Feb-Jun`	Indigenous
37.	*Taverniera cuneifolia* (Roth) Arn.	Fabaceae	Under shrub	Aug-Nov	Indigenous
38.	*Urochondra setulosa* (Trin.) C.E.Hubb.	Poaceae	Perennial	Oct-Jan	Indigenous
Land vegetation					
Prosopis occupied area					
39.	*Acacia nilotica* ssp. *indica* (Benth.) Brenan	Mimosaceae	Tree	Jul-Oct	Indigenous
40.	*Prosopis juliflora* (Sw.) DC.	Mimosaceae	Tree	Aug-May	Exotic
Bunds					
41.	*Abutilon indicum* (L.) Sweet ssp. *indicum*	Malvaceae	Shrub	Throughout	Indigenous
42.	*Achyranthes aspera*L. var. *Aspera*	Amaranthaceae	Herb	Throughout	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
43.	*Alternanthera sessilis* (L.) R. Br. ex DC.	Amaranthaceae	Herb	Throughout	Indigenous
44.	*Azadirachta indica* A. Juss.	Meliaceae	Tree	Dec-May	Indigenous
45.	*Calotropis procera* (Aiton)R. Br.	Asclepiadaceae	Shrub	Throughout	Indigenous
46.	*Corchorus olitorius* L.	Tiliaceae	Herb	Aug-Dec	Indigenous
47.	*Corchorus trilocularis* L.	Tiliaceae	Herb	Jul-Mar	Indigenous
48.	*Leucaena leucocephala* (Lam.) de Wit.	Mimosaceae	Tree	May-Feb	Exotic
49.	*Parkinsonia aculeata* L.	Caesalpiniaceae	Shrub	Nov-Mar	Exotic
50.	*Parthenium hysterophorus* L.	Asteraceae	Herb	Sep-Mar	Exotic
51.	*Passiflora foetida* L. var. *Foetida*	Passifloraceae	Climbing shrub	Aug-Dec	Exotic
52.	*Pentatropis spirallis* (Forssk.) Decne	Asclepiadaceae	Twining herb	Aug-Dec	Indigenous
53.	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Tree	Jan-Mar	Indigenous
54.	*Physalis minima* L.	Solanaceae	Herb	Jul-Jan	Indigenous
55.	*Pithecellobium dulce* (Roxb.) Benth.	Mimosaceae	Tree	Jan-Jul	Exotic
56.	*Pluchea lanceolata* (DC.) C.B.Clarke	Asteraceae	Herb	Jan-Apr	Indigenous
57.	*Senna auriculata* (L.) Roxb.	Caesalpiniaceae	Shrub	Jan-Jul	Indigenous
58.	*Setaria pumila* (Poir.) Roem. & Schult.	Poaceae	Annual	Jul-Nov	Indigenous
59.	*Sporobolus virginicus* (L.) Kunth	Poaceae	Perennial	Aug-Dec	Indigenous
60.	*Stemodia viscosa* Roxb.	Scrophulariaceae	Herb	Oct-May	Indigenous
61.	*Tamarix indica* Willd.	Tamaricaceae	Tree	Aug-Mar	Indigenous
62.	*Vernonia cinerea* (L.) Less.	Asteraceae	Herb	Throughout	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
Open land					
63.	*Aloe vera* (L.) Burm. f.	Liliaceae	Herb	Dec-May	Exotic
64.	*Aristida adscensionis* L.	Poaceae	Annual	Aug-Jan	Indigenous
65.	*Capparis decidua* (Forssk.) Edgew.	Capparaceae	Shrub	Feb-Sep	Indigenous
66.	*Cenchrus ciliaris* L.	Poaceae	Annual	Jul-Jan	Indigenous
67.	*Chenopodium album* L.	Chenopodiaceae	Herb	Nov-Apr	Indigenous
68.	*Chloris barbata* Sw.	Poaceae	Perennial	Jul-Apr	Indigenous
69.	*Clerodendron phlomoides* (L.) Moon	Verbenaceae	Shrub	Jun-Dec	Indigenous
70.	*Clitoria ternetea var. ternetea f. albiflora*	Fabaceae	Climbing herb	Throughout	Exotic
71.	*Clitoria ternetea var. ternetea f. ternetea*	Fabaceae	Climbing herb	Throughout	Exotic
72.	*Coccinia grandis* (L.) Voigt	Cucurbitaceae	Climbing herb	Throughout	Indigenous
73.	*Cocculus hirsutus* (L.) W. Theob.	Menispermaceae	Climbing shrub	Nov-Apr	Indigenous
74.	*Cordia dichotoma* G. Forst.	Boraginaceae	Tree	Jan-Jun	Indigenous
75.	*Ctenolepis cerasiformis* (Stocks) Hook. f.	Cucurbitaceae	Climbing herb	Aug-Oct	Indigenous
76.	*Cucumis maderaspatanus* L.	Cucurbitaceae	Climbing herb	Jul-Nov	Indigenous
77.	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	Annual	Throughout	Indigenous
78.	*Elytraria acaulis* (L. f.) Lindau	Acanthaceae	Herb	Jul-Dec	Indigenous
79.	*Enicostema axillare* (Lam.) A. Raynal ssp. *axillare*	Gentianaceae	Herb	Jul-Nov	Indigenous
80.	*Eragrostis ciliaris* (L.) R. Br.	Poaceae	Annual	Oct-Jan	Indigenous
81.	*Fagonia schweinfurthii* (Hadidi) Hadidi ex Ghafoor	Zygophyllaceae	Undershrub	Oct-Dec	Indigenous

SN	Botanical name	Family	Habit	Phenology	Origin
82.	*Indigofera oblongifolia* Forssk.	Fabaceae	Shrub	Sep-Oct	Indigenous
83.	*Justicia procumbens* L.	Acanthaceae	Herb	Jun-Dec	Indigenous
84.	*Solanum virginianum* L.	Solanaceae	Herb	Throughout	Indigenous
85.	*Ziziphus mauritiana* Lam. var. *mauritiana*	Rhamnaceae	Shrub	Sep-Feb	Indigenous
86.	*Zizyphus nummularia* (Burm. f.) Wight. & Arn. var. *Nummularia*	Rhamnaceae	Shrub	Jul-Jan	Indigenous

4.1.2 Phytosociology

4.1.2.1. Phytosociologial analysis of Gosabara

In Gosabara wetland complex, ten tree species were recorded during the survey of which 3 dominant species of tresswere considered for IVI analysis*i.e.Prosopis juliflora, Avicennia marina* and *Salvadora persica. Prosopis juliflora* is the dominant tree species in Gosabara with maximum IVI value *i.e.* 198.2. *Prosopis* is invaded in the open land area of wetland and the prosopis cover may be increase due to grazing of seeds by the cattles or by in sufficient rains. During frequency analysis prosopis showed highest frequency count which indicates even distribution of the species in tree community in almost all the sites of the wetland complex. A small pocket of Mangrrove near Shubhash Nagar Bridge is mainly dominated by *Avicennia marina* with IVI value 57.7 having highest abundance value. *Salvadora persica* is salt loving tree and its population size is very small covering small pockets on bunds. The species has very less IVI value i.e. 43.8 compared to other two tree species because of its restricted disrtbution (Table 4).

104 Species of herbs were recorded during the survey of which seven dominant species were considered for IVI analysis.In the herbaceous community; the individuals of all the species are not evenly distributed. Individuals of some species are wildely spaced while those of some other species are found in clumps and mats. *Schoenoplectus subulatus* is the dominant sedge with maximum IVI value 72.7and highest frequency and density that shows its even distribution in all the sites of wetland followed by *Cressa cretica, Bolboschoenus maritimus* and*Aeluropus lagopoides* with IVI 31.3, 28.3 and 16.1 respectively.The distribution patterns of individuals of different species indicate their reproductive capacity and adaptability to the environment. *Schoenoplectus* is found to be most frequent and adjustable species for wetland area. Though, species like *Suaeda nudiflora, Halopyrum mucronatum* and *Salicornia brachiata* have IVI value less than 5.5 which states that they covers minimum area of the wetland and their distribution is restricted to some parts of the wetland but they were abundantin salinepockets.

The value of Sinmpson index of diversity ranges between 0-1, the greater the value the greater the sample diversity. In our floral diversity study for Gosabara the Simpson index of diversity value is 0.78 which indicates comparatively rich diversity of floristic diversity in Gosabara Wetland complex.

Table 4: Phytosociological analysis of Gosabara

S.N.	Species	Frequency %	Abundance	Density	Relative frequency %	Relative Density %	Relative Dominannce %	IVI
Herbs (m^{-1})								
1.	*Aeluropus lagopoides*	8.5	434	37.01	5.8	10.4	-	16.1
2.	*Bolboschenous maritimus*	22.7	202	46	15.4	12.9	-	28.3
3.	*Cressa cretica*	40	37	15	27.1	4.2	-	31.3
4.	*Halopyrum mucronatum*	3.6	182	6.5	2.4	1.8	-	4.3
5.	*Heliotropium supinum*	2.9	5	0.15	1.9	0.04	-	2.0
6.	*Aeluropus lagopoides*	6.7	49	2.4	4.5	0.5	-	5.1
7.	*Bolboschenous maritimus*	14.3	11	1.5	9.7	0.4	-	10.1
8.	*Cressa cretica*	48.8	289	141.2	33.1	39.6	-	72.7
Trees (ha^{-1})								
9.	*Avicennia marina*	11.0	26000	2737	10.5	14.0	33.2	57.7
10.	*Prosopis juliflora*	86.0	18955	16228	85.6	83.2	29.4	198.2
11.	*Salvadora persica*	4.0	13727	530	3.85	2.7	37.3	43.8
Regeneration(ha^{-1})								
12.	*Prosopis juliflora*	85	5	3.9	96.3	99.2	-	-
13.	*Salvadora persica*	3	1	0.03	3.7	0.8	-	-

4.1.2.1. Phytosociologial analysis of Khijadiya

From Khijadiya Sanctuary eleven species of trees were recorded of which three dominant species *i.e.Prosopis juliflora, Avicennia marina* and *Salvadora persica* were taken for IVI studies. *Prosopis julifora* is the most dominant invasive species of the sanctuary spreaded in whole sanctuary with maximum IVI value of 147.7. The species is also invaded in the water pockets and open land which hinders the growth of other plants and decrease faunal diversity. A big patch of mangroove was their in the part 1 of the sanctuary which is mainly dominated by *Avicennia marina*with 82.1 IVI value and highest abundance. The species is restricted to the salt marsh area but dominant in that area. *Salvadora persica* has sparse distribution and found on bunds and some individuals are found be scattered on some sites with 66.0 IVI value which indicates that the species is not widely spreaded and also has lowest abundance value (Table 5).

51 species of herbs were recorded of which sevendominant species were taken for IVI analysis. *Cressa cretica* is the most dominant species with IVI of 73.2 followed by *Aeluropus lagopoides, Schoenoplectus subulatus, Urochondra setulosa, Arthrocnemum indicum, Chrozophora plicata* and*Glinus lotoides* with their IVI values 30.6, 26.1, 16.0, 15.6, 11.2 and 10.1 respectively.*Cressa cretica* is having highest frequency and density followed by *Arthrocnemum, Crozophora, Glinus, Schoenoplectus, Urochondra* and *Aleuropus* which indicates the distribution pattern of this species in the area where *cressa* is evenly distributed in all the parts of the sanctuary. As *Cressa* is dry puddle species and found on the saline grounds; so once the drying of water gets starts the *Cressa* spreads all over the area being dominant herb in the area. Small patch of *Urochondra* was located in association with *Arthrocnemum*with less IVI value but the species are abundant in that area due the restricted distribution with highest abundance value.

Simpson diversity is the measure of diversity. The value of Simpson index of diversity for Khijadiya is 0.76 which indicates comparatively good floral diversity from the prospective of aquatic pockets.

Table 5: Phytosociological Analysis of Khijadiya

S.N.	Species	Frequency %	Abundance	Density	Relative frequency %	Relative Density %	Relative Dominance %	IVI
Herbs (m^{-1})								
1.	*Aeluropus lagopoides*	8.5	265.7	22.6	7.3	23.3	-	30.6
2.	*Arthrocnemum indicum*	16.0	10.5	1.7	13.8	1.7	-	15.6
3.	*Cressa cretica*	51.3	54.6	28.0	44.4	28.8	-	73.2
4.	*Chrozophora plicata*	11.8	8.4	1.0	10.2	1.0	-	11.2
5.	*Urochondra setulosa*	8.5	99.2	8.4	7.3	8.7	-	16.0
6.	*Glinus lotoides*	10.8	6.9	0.7	9.3	0.8	-	10.1
7.	*Schoenoplectus subulatus*	8.8	203.2	17.9	7.6	18.5	-	26.1
Trees (ha^{-1})								
8.	*Avicennia marina*	30.7	38800	11900	29.2	30.6	22.3	82.1
9.	*Prosopis juliflora*	69.3	36100	25000	66.0	64.4	17.3	147.7
10.	*Salvadora persica*	5.0	7400	400	4.7	0.9	60.4	66.0
Regeneration (ha^{-1})								
11.	*Prosopis juliflora*	93.3	10	10.2	100.0	93.1	-	-

4.1.3 GIS MAPPING

4.1.3.1 Gosabara

- Gosabara wetland complex coveres a total of 129 square kilometre area.GIS maps were prepared for both the seasons, post monsoon (7th November 2015) and summer (15th April 2016). The change in the area of sub habitats of wetland during both the season is given below (Figure 6, Mapp 3 & 4).

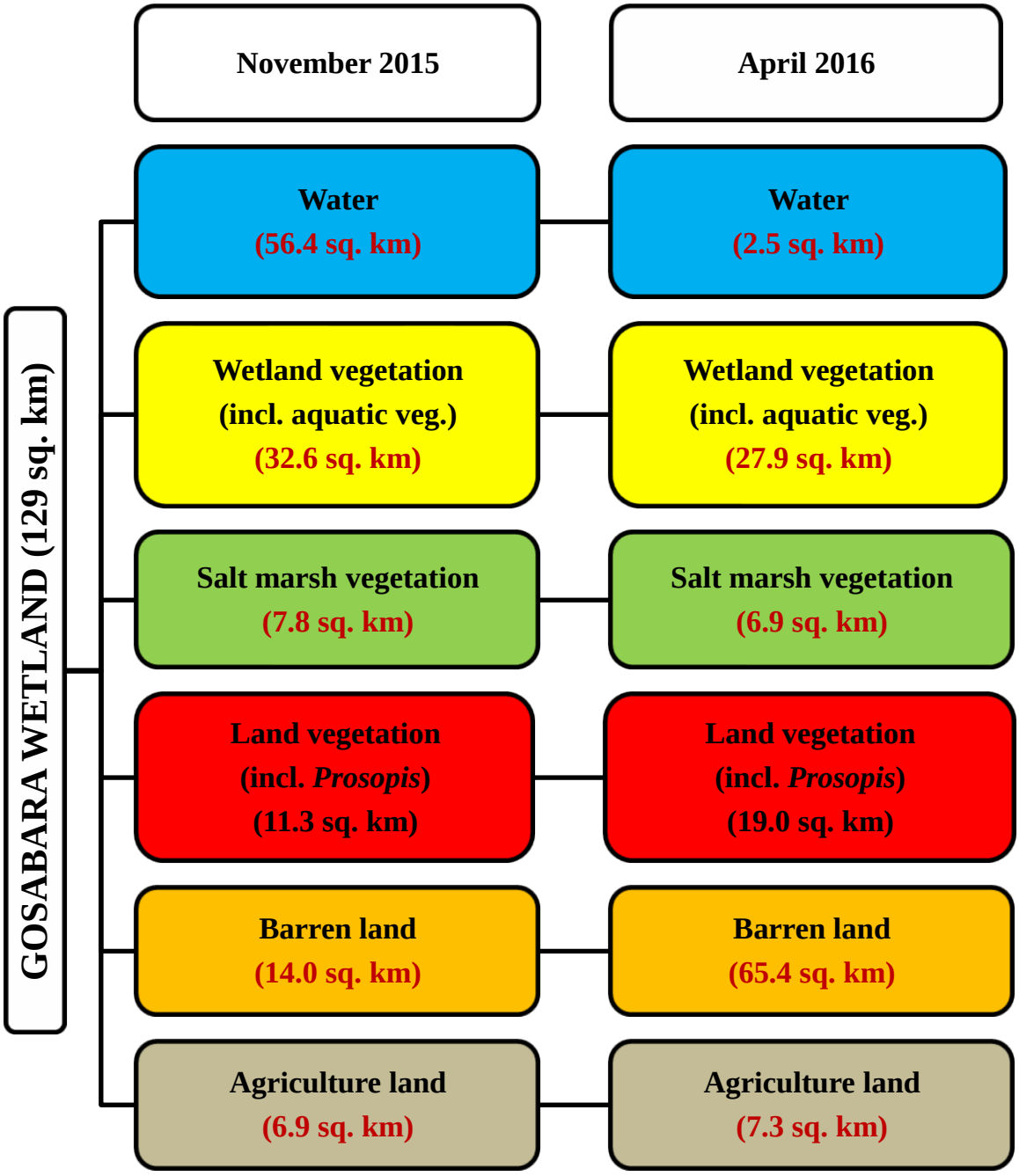
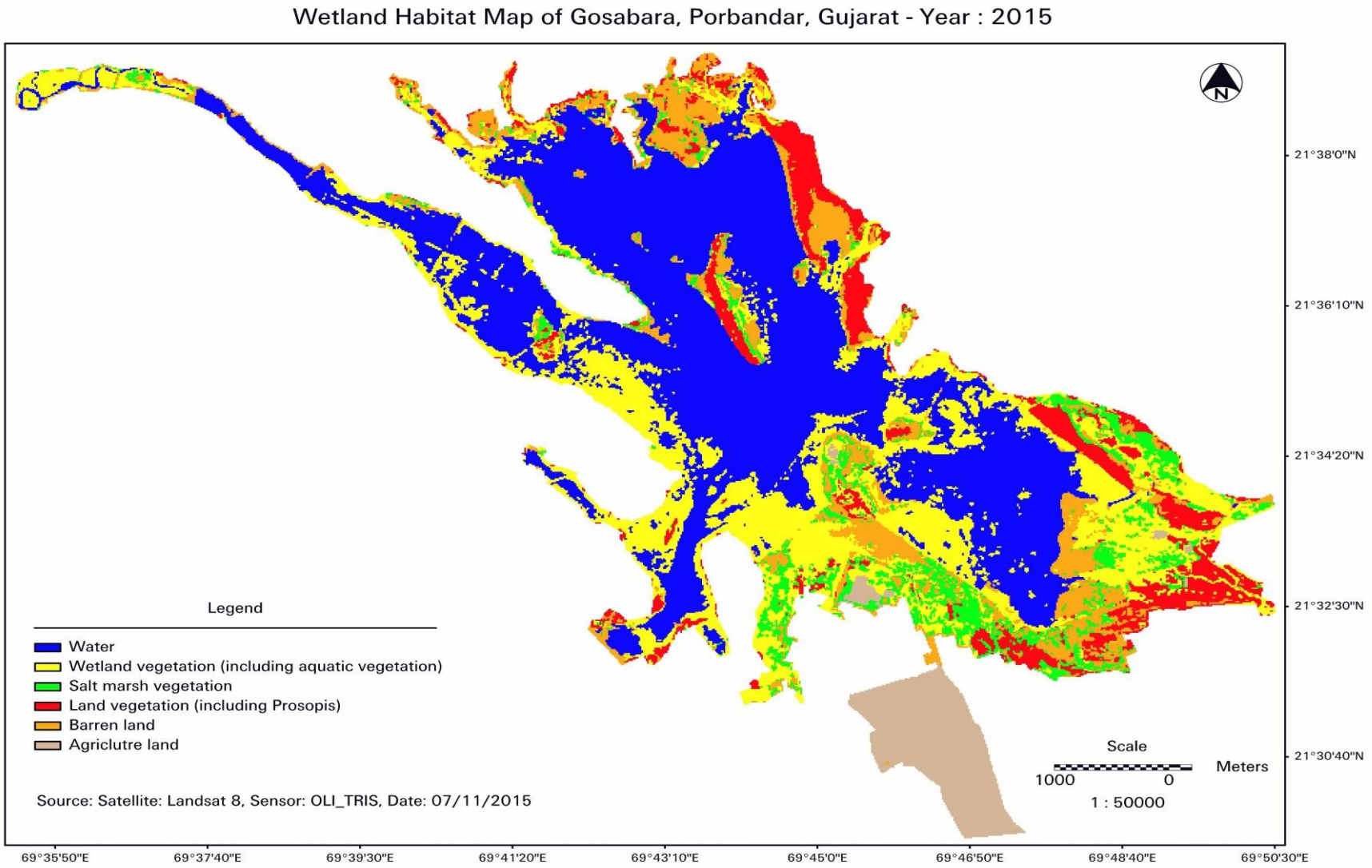
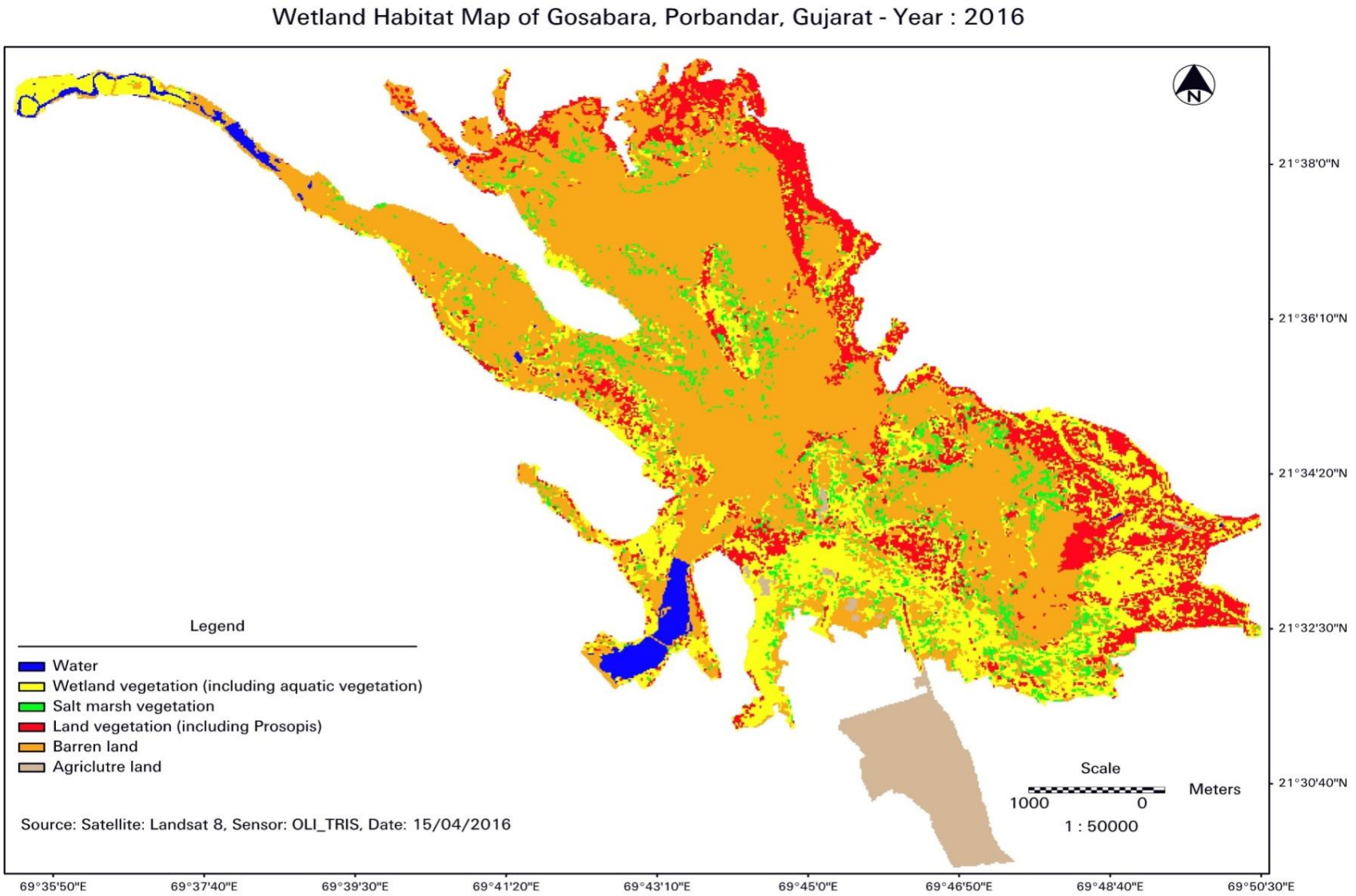


Figure 6: Change in Sub-habitats during Post-monsoon and Summer



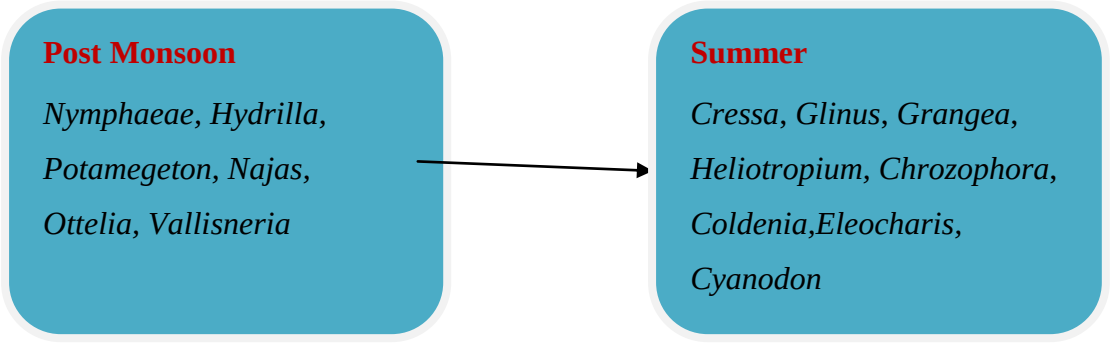
Map 3: GIS Map of Gosabara (07/11/2015)



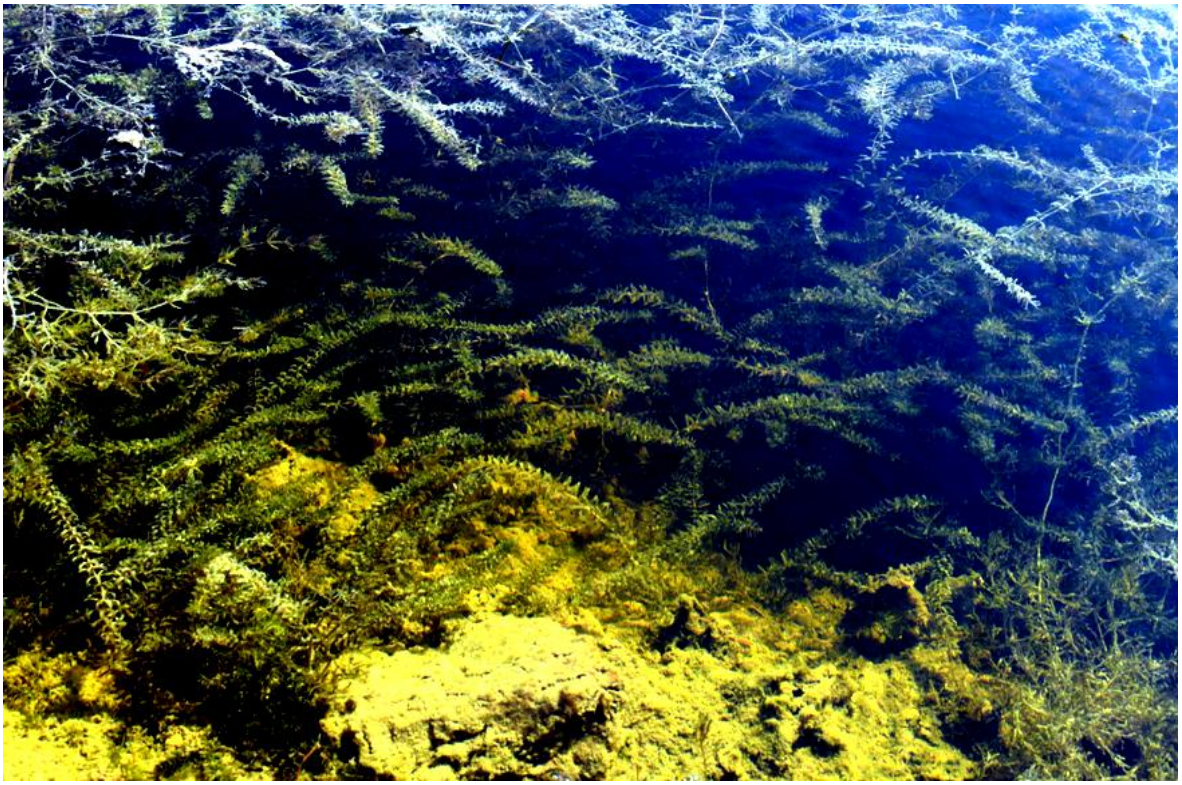
Map 4: GIS Map of Gosabara (15/04/2016)

The changes in these sub-habitats during post monsoon and summer are as follows:

- **Sub-Habitat I (Water):** The area covered by the habitat during post monsoon (November 2015) period was56.4 sq.km.which was gradually reduced to 2.5 sq. km by summer (April, 2016). In the process of drying the submerged and floating aquatic vegetation was gradually occupied by dry puddle vegetation (*Cressa cretica*, *Glinus lotoides*, *Grangea madraspatensis*, *Heliotropium curssavicum*, *Heliotropium supium*, *Chrozophora rottleri*, *Coldenia procumbens*, *Eleocharis geminatum* etc.) and grass carpets (*Cynodon dactylon*, *Paspalum vaginatum*, *Sporobolus virginicus*, *Aeluropus lagopoides*). The change in the vegetation pattern is given in the below text box with dominant species.

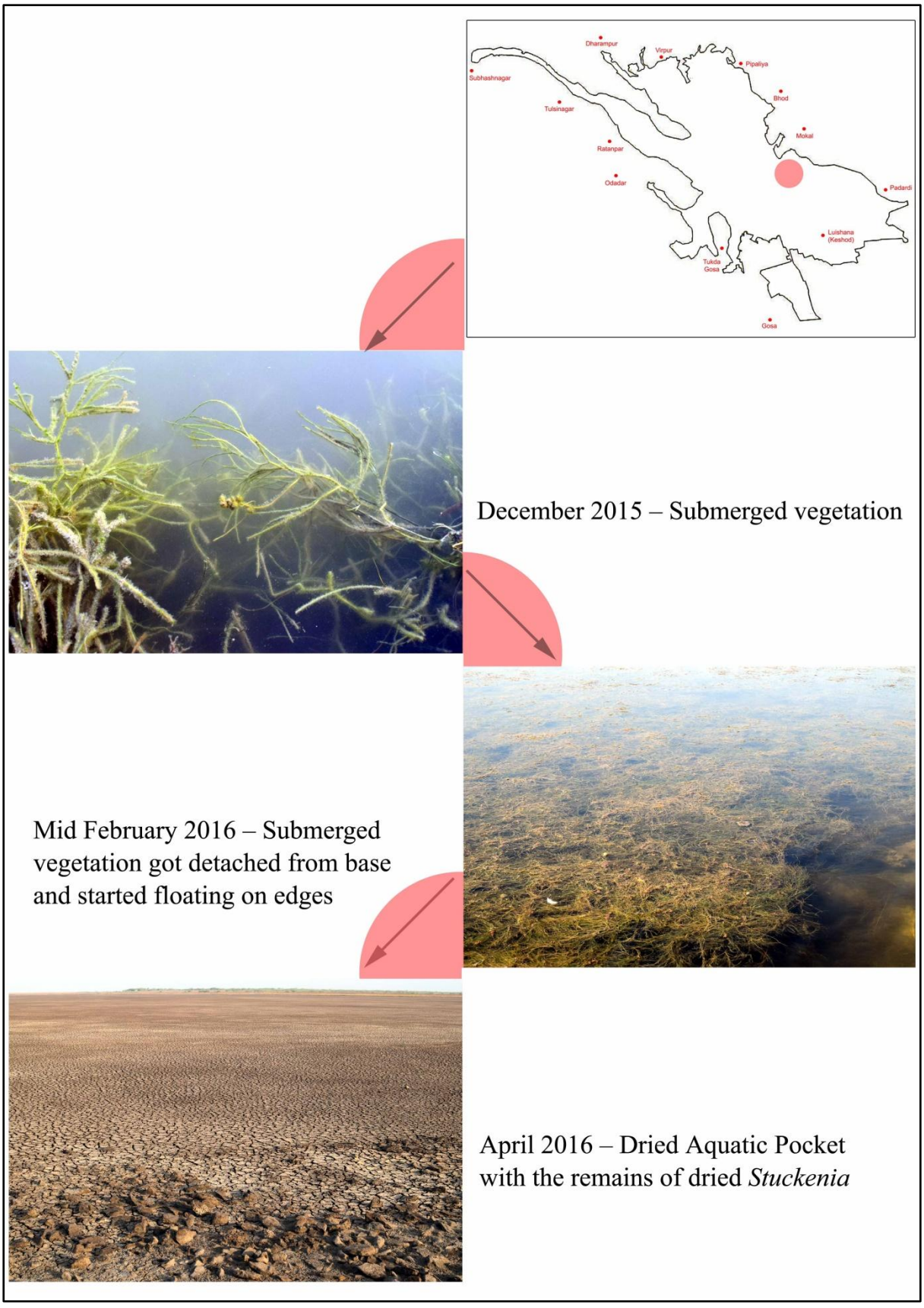


Aquatic pockets were occupied by grass carpet (*Cynodon dactylon*) during summer near Tukda Gosa site



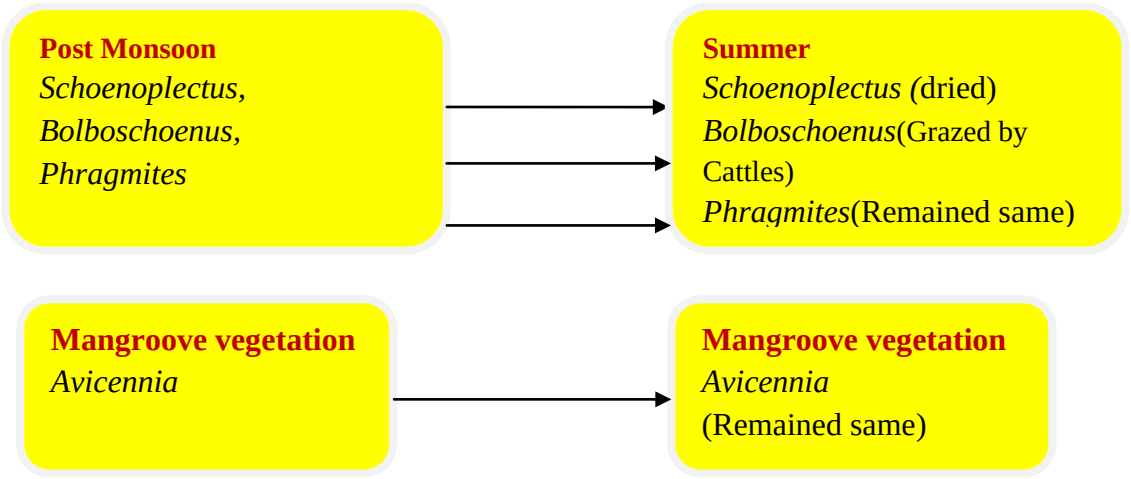
***Hydrilla* community established at Dharampur and Odadar sites.**

***Ottelia* community established at Virpur site**

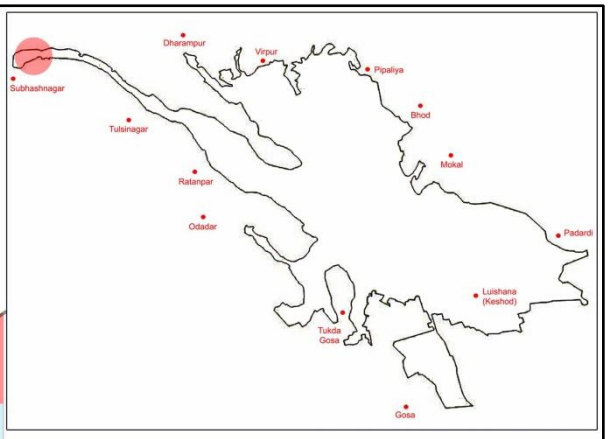


Changes in the habitat from aquatic (*Stuckenia*&*Najas*) to barren land in Mokar site

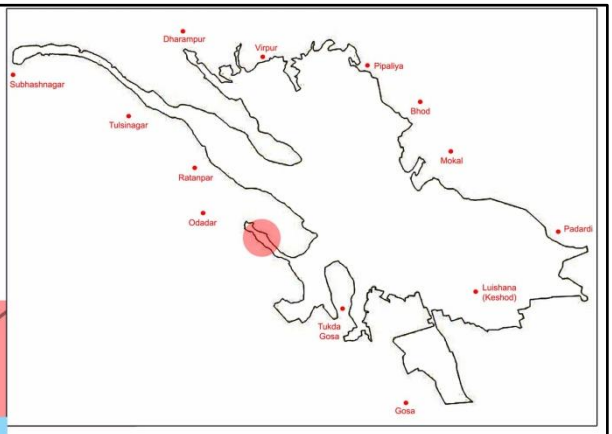
- **Sub-Habitat II (Wetland vegetation):** The area under this sub-habitat during post-monsoonal period was 32.6 sq. km which gradually reduced to 27.9 sq. km during summer. Wetland vegetation includes *Schoenoplectus*, *Bolboschoenus* and *Phragmites* on the edges of water body and during summer this vegetation got dried. *Bolboschoenus* was grazed by the cattles.



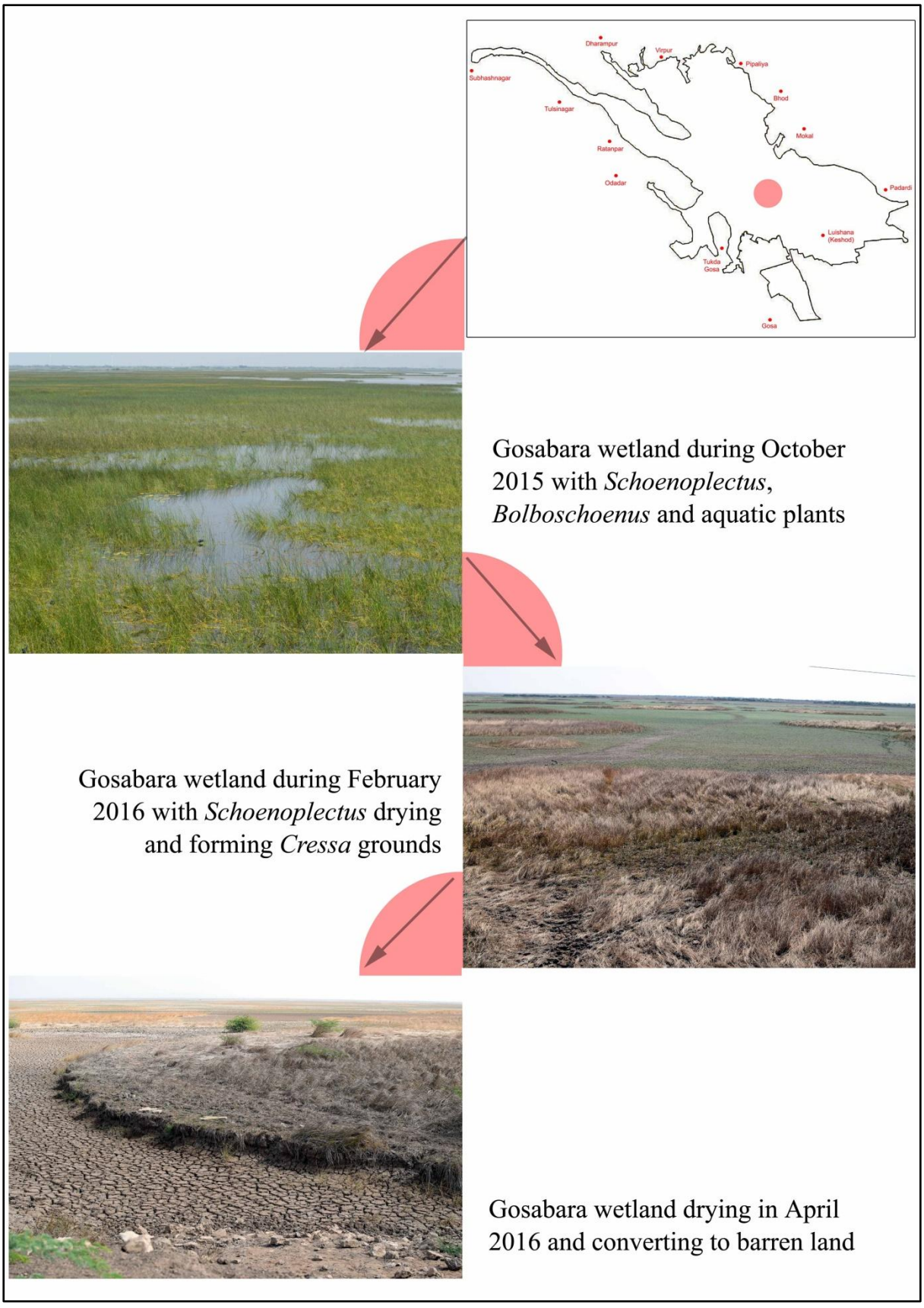
***Bolboschoenus* and *Schoenoplectus* community at Odadar island site**



Avicennia marina community towards Subhasnagar



Typha and *Phragmites* community towards Odadar site



Change in the habitat from November-April

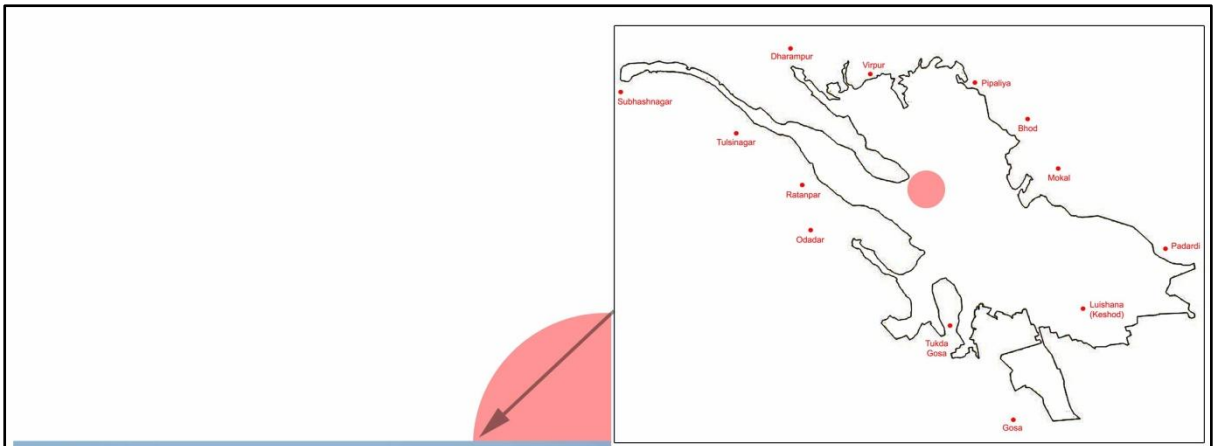
- **Sub-Habitat III (Salt marsh):** The area under this pocket was increased owing to drying of water pocket and increase in salinity due to lowering of water table. The central zone of Gosabara which was fully merged under water during Post monsoon period gradually got dried and was later occupied by *Salicornia*, *Suaeda*, *Arthrocnemum* and *Cressa*.

Post Monsoon
Suaeda, *Arthrocnemum*, *Aeluropus*, *Cressa*

→

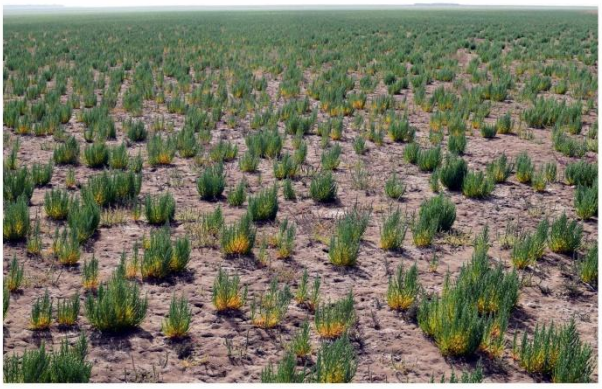
Summer
Suaeda, *Arthrocnemum* (Dried), *Aeluropus* (Dried), *Cressa*, *Salicornia*

***Suaeda nudiflora* community at Keshod (Lushana) site**



Schoenoplectus community in the Gosabara wetland during October 2015

Wetland during February 2016 dried, *Cressa* in flowering and *Salicornia* growing gradually, while *Schoenoplectus* dried



Salicornia getting established over the dried wetland in April 2016

Change in the habitat from November-April

- **Sub-Habitat IV (Barrenland):** This habitat was initially 15 sq. km which has gradually increased to 65 sq. km.This increases is owing to the drying of wetland during the span four months. The barren land includes the sandy beach area where the vegetational area is not that much large so in GIS mapping it was considered as barren land but some vegetational diversity has been found which is given in the below text box.

Post Monsoon
Convolvulus, Halopyrum, Heliotropium bacciferum, Lotus, Polycarpaea, Launaea, Cyperus

→

Summer
Halopyrum, Heliotropium bacciferum, Lotus, Cyperus

***Halopyrum mucronatum* community at the sandy beach of Tukda Gosa site**

***Cressa cretica* growing on the barren land at Keshod (Lushana) site**

***Prosopis* felled in the periphery of the Gosabara wetland near Bhod site**

***Alhagi maurorum* community established at Tukda Gosa site**

- **Sub-Habitat V (Agriculture):** The agriculture area has reduced from Post monsoon to Summer owing to lack of fresh water. However the agriculture areas attacts many birds like Demoiselle crane during the post-harvested period of groundnut and chickpea. There are other cultivated species such as*Pennissetum glaucum* (Bajro), *Daucus carota* (Carrot), *Ricinus communis* (Castor), *Cocos nucifera* (Coconut), *Gossypium herbaceum* (Cotton), *Coriander sativum* (Dhaniya), *Medicago sativa* (Gadab), *Arachis hypogaea* (Ground nut), *Cuminum cyminum* (Jeeru), *Sorghum bicolour* (Juwar), *Raphanus sativus* (Muli), *Solanum lycopersicum* (Tomato) and *Triticum aestivum* (Wheat).

Barren cumin field gradually occupied by *Cressa cretica* towards Pipaliya site

Demoiselle cranes feeding on groundnut field near Padardi site

4.1.3.2 Khijadiya

- Khijadiya bird sanctuary covers a total of 19 square kilometre area. The GIS map of the study area was prepared for Post monsoon (7th November 2015) and summer season. The site has been divided in to six sub habitats based on the area covered by various habitat or vegetation (Fig 7, Map 5 & 6).

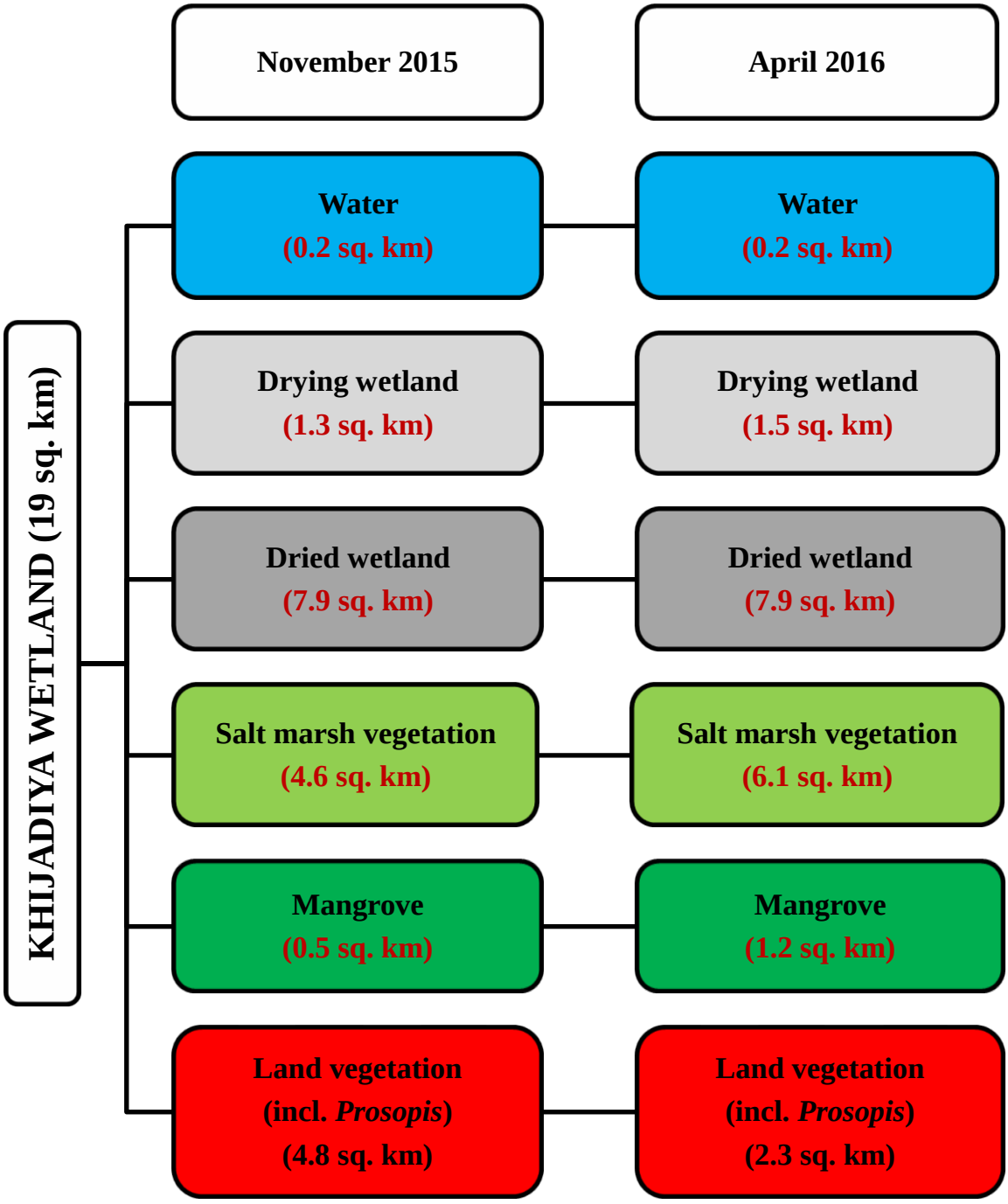
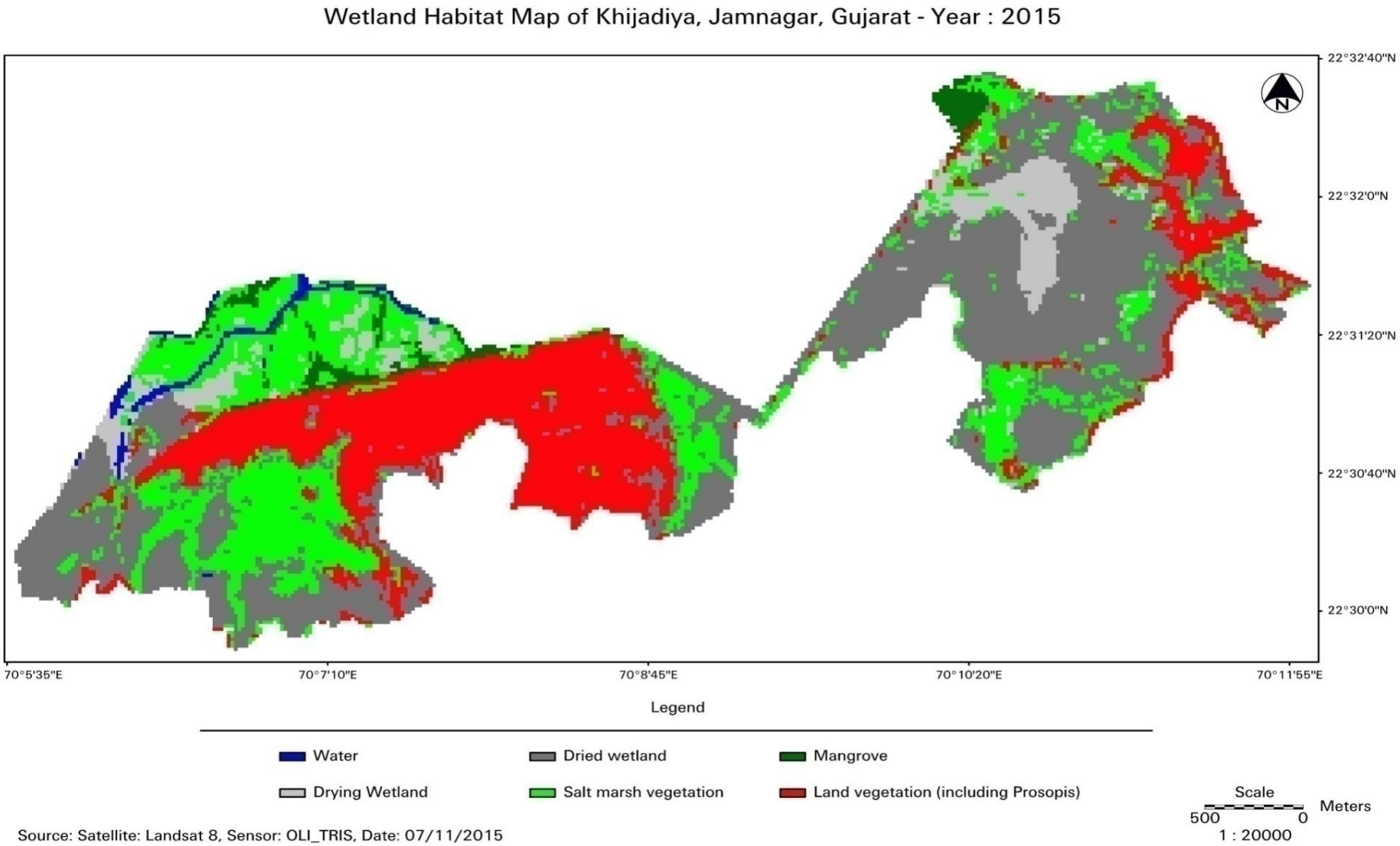
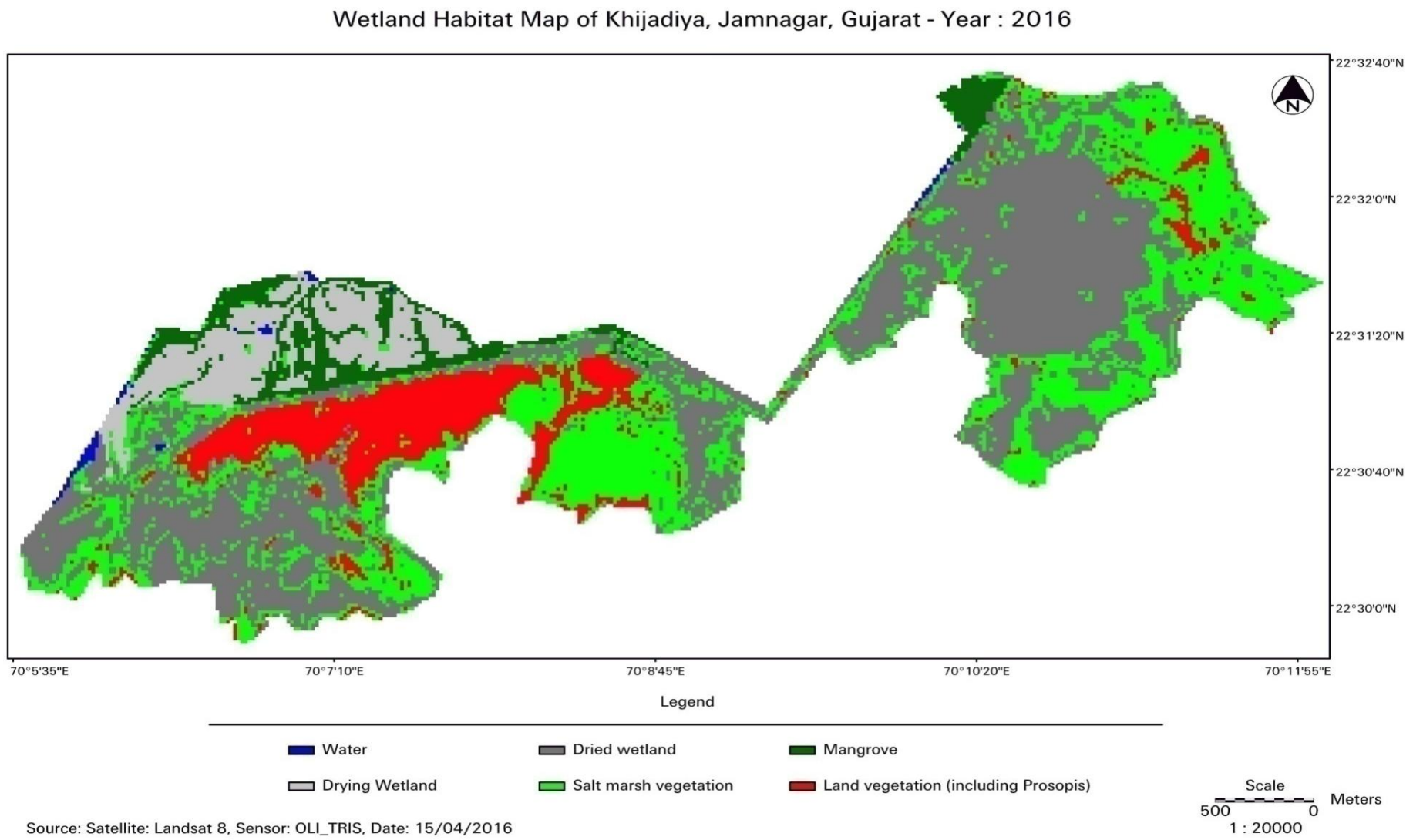


Figure 7: Change in Sub-habitats during Post-monsoon and summer in Khijadiya

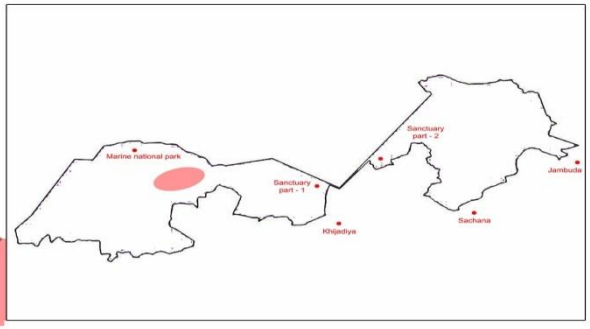


Map 5: GIS Map of Khijadiya (07/11/2015)



Map 6: GIS Map of Khijadiya (15/04/2016)

- **Sub habitat 1 – Water:** The area covered by water has remained the same. No aquatic vegetation has been located.
- **Sub Habitat 2 – Drying Wetland:** The area covered by this sub habitat was increased from 1.3 sq.km. to 1.5 sq.km from post monsoon to monsoon. *Bolboschoenus, Phragmitis* and *Schoenoplectus* have been located from this area which gradually got dried over a period of time.
- **Sub Habitat 3 – Dried Wetland:** The area covered by dried wetland has remained the same.
- **Sub Habitat 4 – Salt Marsh Vegetation:**The area under salt marsh was increased from 4.6 to 6.1 sq.km over a period of time. The species like arthrocnemum and urochodra has formed the big patches in this area.
- **Sub Habitat 5 – Mangroove:** The mangroove vegetation has also been increased from 0.5 to 1.2 sq. km. over a period of time.
- **Sub Habitat 6 – Land Vegetation:** Land vegetation includes species located from open land. Prosopis juliflora is the dominant invasive species of land vegetation.The area coverd by *Prosopisjuliflora* and other land vegetation was decreased from 4.8 to 2.3 sq. km due to removal of *Prosopis* from the site which will help in the restoration of water during rains (*c.f.* Map 5 & 6).
- The cultivated species such as *Pennissetum glaucum* (Bajro), *Ricinus communis* (Castor), *Gossypium herbaceum* (Cotton), *Coriander sativum* (Dhaniya), *Arachis hypogaea* (Ground nut), *Cuminum cyminum* (Jeeru), *Sorghum bicolour* (Juwar) and *Ziziphus mauritiana* (Khat bor) are grown in the surrounding buffer zone of Khizadia.



Khijadiya sanctuary part-I, during October 2015

Khijadiya sanctuary part-I, dried in March 2016 with dry puddle vegetation

Khijadiya sanctuary part-1, during December 2015, roadside invaded by *Prosopis juliflora*

Khijadiya sanctuary part-1, roadside *Prosopis* felled during April, 2016

4.1.4 BIOCHEMICAL PARAMETERS OF SOIL

4.1.4.1 Gosabara

- **Total Nitrogen/Organic carbon**

The soil having good amount of total nitrogen or organic carbon is good for agriculture practices. So, site 1 and 5 are of good quality for agriculture practicies (Table 6).

- **Phosphate and Potassium**

The phosphate content was low at all the sites and the amount of potassium was highest in all sites except Dharampur.

- **pH and Conductivity (EC)**

Soil pH affects the soil's physical, chemical and biological properties and processes, as well as plant growth. The nutrition, growth and yields of most crops will decrease where pH is low and increase as pH rises to an optimum level. Most of the crops grow best if pH is close to neutral (pH 6 to 7.5). The soil of site 2, 4 and 6 has pH in a range of 6-7.5 which is good for agricultural practices. EC is high in Site 1, 5 and 6 and medium in site 2 and 3 (Table 6).

- At site 1 and 2 *Salicornia* and *Arthrocnemum* forms the major and unique vegetation. *Creea* is the dominanting and most frequent species at all the areas of Gosabara

Table 6: Soil analysis of Gosabara

Parameters	1 (Chhaya)		2 (Dharampur)		4 (Tukda Gosa)		5 (Mokar)		6 (Keshod)	
Total Nitrogen/Organic Carbon (OC)%	0.94	High	0.38	Low	0.63	Medium	0.99	High	0.65	Medium
P_2O_5,kg/Ac	6.00	Low	6.00	Low	7.00	Low	7.00	Low	7.00	Low
K_2O,kg/Ac	283.00	Very high	123.00	High	240.00	Very high	525.00	Very high	395.00	Very high
pH 1:2	8.10	Neutral	7.42	Neutral	7.29	Neutral	7.80	Neutral	7.07	Neutral
EC 1:2	1.90	High salinity	0.55	Medium salinity	0.62	Medium salinity	11.90	Extremely high-salinity	2.97	Very high-salinity
Representative Vegetation	***Cressa, Arthrocnemum, Salicornia***		***Bacopa, Arthrocnemum, Salicornia***		***Alhagi, Cynodon, Sporobolus, Glinus***		***Cressa, Suaeda, Heliotropium, Grangea, Aeluropus***		***Cressa, Suaeda, Tamarix, Aeluropus***	

4.1.4.2 Khijadiya

Table 7 shows that Total Nitrogen/Organic Carbon content was more in Part 1 and 2 of the sanctuary due to the decomposition plant debris. Phosphate content is low and Potassium is high in all the sites. The soil is vey saline having neutral pH which is not good for agariculture practices.

Table 7: Soil analysis of Khijadiya

Parameters	**1**(Part 1)		**2 (Part 2)**		**3 (Jambuda, Mangroove pocket)**	
Total Nitrogen/Organic Carbon (OC)%	0.98	High	1.05	High	0.73	Medium
P_2O_5,kg/Ac	8.00	Low	6.00	Low	6.00	Low
K_2O,kg/Ac	230.00	Very high	275.00	Very high	245.00	Very high
pH 1:2	7.33	Neutral	8.09	Neutral	8.28	Alkali
EC 1:2	17.88	Extremely high-salinity	17.67	Extremely high-salinity	4.79	Very high-salinity
Representative Vegetation	***Glinus, Chrozophora, Grangea***		***Cressa, Tamarix, Suaeda***		***Avicennia, Urochondra, Arthrocnemum***	

4.1.5 BIOCHEMICAL PARAMETERS OF WATER

4.1.5.1 Gosabara

During the study six collected water samples were analysed for pH, conductivity, TDS, DO, Nitrite, Nitrate, Phytoplankton density and diversity. The pH and conductivity are range for all the samples except site 3 were the conductivity is very high because this site site is nearer to Sea. At site 1 the phytoplankton diversity is highest but density is low dute to higher amount of nitrate content. More amount of nitrate leads to decrease on phytoplankton density. At site 4 the TDS is very high due to high amount of salts in the water sample and because of that the phytoplankton diversity is comparatively less but density is high. The maximum phytoplankton count was 3400 at site 5 where, the nitrite content is highin comparision to nitrate. At site 1 the phytoplankton density minimum might be due to the low dissolved oxygen, and the high amount of Nitrtae. Dissolved Oxygen (DO) content is in a range at all the site of Gosabara. The water of site 5 and 6 has highest DO and lowest TDS which is good for drinking purpose. The water of site 4 has comparatively higher conductivity because it is very close to the sea.

Maximum phytoplankton diversity was found at site 1 and minimum at site 3(Table 8). The species like *Chlorella*, *Spirogyra*, *Fragilaria*, *Navicula*, *Nitzschia* and *Nostoc* are the important species of phytoplanktons observed during the study period. *Chlorella* is considered as economically important species used as protein source in aqua feed.

Table 8: Water analysis of Gosabara

Sites	**pH**	**Conductivity (µs/cm)**	**TDS mg/l**	**DO mg/l**	**Nitrite µmol/l**	**Nitrate mg/l**	**Phytoplankton**	**Phytoplankton density L-1**
1 (Chhaya)	8.5	**230**	**150**	2.032	0.037	0.378	17	2750
2 (Dharampur)	8.9	180	110	2.71	0.112	0.278	12	3050
4 (Tukda Gosa)	8.4	**300**	**180**	3.613	0.037	0.079	9	3000
5 (Mokar)	8.4	170	110	4.968	0.187	0.038	9	3400
6 (Keshod)	7.5	190	120	3.952	0.112	0.078	9	3100

4.1.5.2 Khijadiya

During the study three water samples were collected from different sites of Khijadiya Bird Sanctuary. Table 9 shows that in Khijadiya the pH of all the site is in normal range. The conductivity is also in range except site 3 where it is high due to the sea water. TDS is also high in site 3 due to more salt concentration.

Table 9: Water analysis of Khijadiya

Sites	**pH**	**Conductivity** (µs/cm)	**TDS** mg/l	**DO** mg/l	**Nitrite** µmol/l	**Nitrate** (mg/l)	**Phytoplankton**	**Phytoplankton density**
1 (Part 1)	7.9	210	130	-	-	0.046	10	2000
2 (Part 2)	8.3	130	190	-	-	0.156	8	2400
3 (Jambuda, Mangroove pocket)	8.3	330	210	-	-	0.188	10	2500

A total of 11 species of phytoplanktons were identified from Khijadiya. *Amphora, Fragilaria, Navicula*, *Raphidiopsis* and *Euglena* are the five genera which were located from all the water samples colllcted from Khijadiya. The maximum phytoplankton count was 2500 at site 3. Over a period of time increase in the phytoplankton count was observed.

Out of three sites 1and 5 have equal species of phytoplanktons and site 2 has comparatively less species. The species like *Fragilaria, Navicula, Nitzschia* and *Nostoc* are the important species observed during the study period (Table 9).

4.2 THREAT ASSESSMENT

- **Straying of birds by polythene bags**

A line of plastic strips or polythene bags is tied with sticks planted like a flag in the field, as the flags make noise in the wind and scare away the birds. But, as polythene is a non-biodegradable product, if they fall to the ground and get buried they could harm the soil. Thus, farmers should be made aware about the environmental consequences of using plastic.

Agricultural Field of Jeeru (Mokar)

- **Algal Blooms**

An algal bloom is a rapid increase or accumulation in the population of algae (typically microscopic) in a water system. Freshwater algal blooms are the result of an excess of nutrients, particularly some phosphates. The excess of nutrients may originate from fertilizers that are applied to land for agricultural purposes. They may also originate from household cleaning products containing phosphorus.Algal blooms have negative impact on the aquatic diversity of flora and fauna due due to high nutrient content prevailing in the water that results in toxins over a period of time if the blooms are severe.

Eutrophication: This feature is only observed in saline pockets at the mouth of Mokarsagar.

Algal blooms (Tukada Gosa, Gosabara,)

- ***Prosopis* Invasion**

Prosopis is the main invasive species of both the wetlands especially in Khijadiya where it covers the maximum area of the sanctuary.Prosopis possess deep roots which lead to the lowering of water table. The growth of Prosopis is very fast and spreads very vigorously inhibiting the growth of other plants. In Khijadiya the Prosopis is spreaded in such an extent that it has covered the water pockets also this may lead to the decrease in the diversity of flora and fauna.

***Prosopis* invasion in Khijadiya**

SUGGESTION FOR SUSTAINABLE DEVELOPMENT

- **Pumping of potable water to agriculture fields**

Anthropogenic pressure such as the pumping of groundwater for irrigation is a major threat for the wetland. But actually it is the main available water source for irrigation and daily use for local community after monsoon. As the area is semi-arid zone and water scarcity is a major problem. The sustainable use of water is needed.

Pumping of water for irrigation, Gosabara

- **Grazing Activity**

Cressa and *Bolboschoenus* are the two main communities which main sources of fodder for the cattle during post-monsoon period. The drying habitat is later on occupied by the Shepherd community (Maldharis/Rabaris) to graze their cattle's. The cattle community is dependent on the *Cressa, Bolboschoenus* and *Schoenoplectus* as a source of their fodder.

Sedges as a source of fodder (Gosabara)

Camel grazing on *Cressa* (Gosabara)

- **Fishing Activity**

Fishing is the major threat to the wetland diversity of Birds and even aquatic plant diversity. It should not be stopped as it is the main source of income for the locals but it should be in sustainable way because due to fishing net the birds gets trapped in to the net and they get died and aquatic plants were also uprooted due to fishing net.

Fishing Activityat Site 1 (Backgound community*Schoenoplectus littoralis)*

4.3 ECONOMICALLY IMPORTANT SPECIES

Economic valuation of 66 plants has been done (Table 10) where the maximum value is of *Acacia nilotica* (27.72) and minimum is of *Hydrilla verticillata, Ipomoea aquatica, Schoenoplectus littoralis, Pavonia ceratocarpa* and *Mollugo pentaphylla* (0.11). The gum of *Commiphora wightii* and *Acacia nilotica* is highly demanded and has highest importance value. *Medicago sativa* has highest fodder value and largely used by the locals as fodder for cattles. *Gossypium stocksii* and *Prosopis juliflora* has highest importance value as fibre and fuel wood respectively.

The weland during post monsoon (October) to summer (November) shows a gradual decline in the population of *Bolboschoenus community*. This is most preferred fodder for cattles. With the gradual decrease in water depth, the intrazonal *Bolboschoenus* community becomes accessible to cattles as a fodder. As the water dries the fodder source switches from *Bolboschoenus* to *Aeluropus, Cynodon dactylon, Paspalum*. Though *Schoenoplectus* is not a preferred grass by cattles but during scarcity they feed upon it, moreover purple moorhen feeds upon its tubers which are rich source of starch for them.

The Barren land during winter to summer is occupied by *Cressa cretica* which becomes a major source of fodder for camel. *Tamarix indica* is a good fencing plant with pink flowers. It forms a good road side tree in Khijadiya. The same can be repeated in other parts of the wetland.

***Tamarix indica* as a good fencing plant with pink flowers**

Table 10: Species of Economic importance

Sn	Species Name	Food/Nutrition	Medicine	Fibre	Fodder	Fuel wood	Fencing	Timber	Dye	Toothbrush	Oil	Gum	TIV
1.	*Abutilon indicum*	-	1	1	-	-	-	-	-	-	-	-	**0.22**
2.	*Acacia nilotica*	3	4	-	-	8	2	8	-	9	-	8	**27.72**
3.	*Achyranthes aspera*	-	5	-	-	-	-	-	-	-	-	-	**2.75**
4.	*Aeluropus logopoides*	-	-	-	7	-	-	-	-	-	-	-	**5.39**
5.	*Alhagi pseudalhagi*	-	-	4	-	-	-	-	-	-	-	-	**1.76**
6.	*Aloe vera*	4	5	-	-	-	4	-	-	-	-	-	**6.20**
7.	*Ammannia baccifera*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
8.	*Argemone mexicana*	-	2	-	-	-	-	-	-	-	1	-	**0.50**
9.	*Aristolochia bracteata*	-	3	-	-	-	-	-	-	-	-	-	**0.99**
10.	*Asphodelus tenuifolius*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
11.	*Avicennia marina*	-	-	-	1	3	-	-	-	-	1	-	**0.92**
12.	*Azadirachta indica*	-	4	-	-	5	-	-	-	8	3	-	**11.00**
13.	*Bacopa monnieri*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
14.	*Barleria prionitis*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
15.	*Boerhavia chinensis*	-	5	-	-	-	-	-	-	-	-	-	**2.75**
16.	*Bolboschoenus maritimus*	2	-	-	8	-	-	-	-	-	-	-	**5.50**
17.	*Cadaba fruticosa*	-	-	-	-	-	3	-	-	-	-	-	**0.99**

Sn	Species Name	Food/Nutrition	Medicine	Fibre	Fodder	Fuel wood	Fencing	Timber	Dye	Toothbrush	Oil	Gum	TIV
18.	*Calotropis gigantea*	-	3	-	-	-	3	-	-	-	-	-	**1.98**
19.	*Calotropis procera*	-	2	-	-	-	2	-	-	-	-	-	**0.88**
20.	*Capparis decidua*	4	2	-	-	-	-	-	-	-	-	-	**1.98**
21.	*Chloris barbata*	-	-	-	5	-	-	-	-	-	-	-	**2.75**
22.	*Coccinia indica*	4	3	-	-	-	-	-	-	-	-	-	**2.70**
23.	*Corchors depressus*	-	4	1	-	-	-	-	-	-	-	-	**1.38**
24.	*Commiphora wightii*	-	-	-	-	-	-	-	-	7	-	10	**15.90**
25.	*Cressa cretica*	-	3	-	6	-	-	-	-	-	-	-	**4.46**
26.	*Datura metel*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
27.	*Dicanthium annulatum*	-	-	-	9	-	-	-	-	-	-	-	**8.91**
28.	*Echinochloa colona*	1	-	-	2	-	-	-	-	-	-	-	**0.50**
29.	*Eclipta prostrata*	-	3	-	-	-	-	-	5	-	-	-	**3.52**
30.	*Enicostemma axillare*	-	4	-	-	-	-	-	-	-	-	-	**1.76**
31.	*Euphorbia nerrifloia*	-	-	-	-	-	7	-	-	-	-	-	**5.39**
32.	*Fagonia schweinfurthii*	-	3	-	-	-	-	-	-	-	-	-	**0.99**
33.	*Fimbristylis ferruginea*	-	-	-	2	-	-	-	-	-	-	-	**0.44**
34.	*Glinus lotoides*	-	-	-	3	-	-	-	-	-	-	-	**0.99**
35.	*Gossypium stocksii*	-	-	10	-	1	-	-	-	-	6	-	**10.60**
36.	*Grewia tenax*	2	-	-	-	1	-	-	-	-	-	-	**0.50**

Sn	Species Name	Food/Nutrition	Medicine	Fibre	Fodder	Fuel wood	Fencing	Timber	Dye	Toothbrush	Oil	Gum	TIV
37.	*Heliotropium supinum*	-	1	-	2	-	-	-	-	-	-	-	**0.50**
38.	*Hydrilla verticillata*	-	1	-	-	-	-	-	-	-	-	-	**0.11**
39.	*Indigofera oblongifolia*	-	1	-	1	-	-	-	2	3	-	-	**1.35**
40.	*Ipomoea aquatica*	1	-	-	-	-	-	-	-	-	-	-	**0.11**
41.	*Lantana camara*	1	1	-	-	-	4	-	-	-	-	-	**1.32**
42.	*Maerua oblongifolia*	-	-	-	-	-	2	-	-	-	-	-	**0.44**
43.	*Medicago sativa*	-	1	-	10	-	-	-	-	-	-	-	**6.66**
44.	*Merremia gangeticum*	-	2	-	1	-	-	-	-	-	-	-	**0.50**
45.	*Mollugo pentaphylla*	-	1	-	-	-	-	-	-	-	-	-	**0.11**
46.	*Mukia maderaspatensis*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
47.	*Nymphaea pubescens*	1	1	-	-	-	-	-	-	-	-	-	**0.22**
48.	*Opuntia elatior*	1	-	-	-	-	5	-	-	-	-	-	**1.98**
49.	*Parkinsonia aculeata*	3	4	-	-	2	4	-	-	-	-	-	**4.65**
50.	*Pavonia ceratocarpa*	1	-	-	-	-	-	-	-	-	-	-	**0.11**
51.	*Paspalidium geminatum*	2	-	-	6	-	-	-	-	-	-	-	**3.52**
52.	*Paspalum scrobiculatum*	3	-	-	6	-	-	-	-	-	-	-	**4.46**
53.	*Pentatropis capensis*	1	2	-	-	-	-	-	-	-	-	-	**0.50**
54.	*Pergularia daemia*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
55.	*Pithecellobium dulce*	9	-	-	-	-	-	-	-	-	-	-	**8.91**

Sn	Species Name	Food/Nutrition	Medicine	Fibre	Fodder	Fuel wood	Fencing	Timber	Dye	Toothbrush	Oil	Gum	TIV
56.	*Pluchea lanceolata*	-	3	-	-	-	-	-	-	-	-	-	**0.99**
57.	*Portulaca quadrifida*	4	2	-	-	-	-	-	-	-	-	-	**1.98**
58.	*Prosopis juliflora*	2	-	-	4	9	3	-	-	-	-	2	**8.80**
59.	*Salvadora oleoides*	5	2	-	-	5	-	7	-	9	-	-	**17.25**
60.	*Senna auriculata*	-	2	-	-	2	-	-	-	-	-	-	**0.88**
61.	*Senna occidentalis*	-	2	-	-	-	-	-	-	-	-	-	**0.44**
62.	*Schoenoplectus subulatus*	-	-	-	1	-	-	-	-	-	-	-	**0.11**
63.	*Sporobolus virginicus*	-	-	-	4	-	-	-	-	-	-	-	**1.76**
64.	*Tamarix indica*	-	-	-	-	2	-	-	-	-	-	-	**0.44**
65.	*Taverniera cuneifolia*	-	2	-	1	-	-	-	-	-	-	-	**0.50**
66.	*Zizyphus nummularia*	5	-	-	-	1	-	-	-	-	-	-	**1.98**

Plate 1: Purple Moorhen feeding upon *Schoenoplectus* tubers

Plate 2: Birds feeding on *Aeluropus logopoides*

Plate 3: *Prosopis* for Baya weaver's nesting

Plate 4: *Prosopis* providing shelter to the Birds

Plate 5: *Prosopis* providing shelter to the Birds (Green Bea eater)

4.3.1 Ethno-botany:

Local people (villagers), aged persons and farmers were interviewed and sometimes taken for excursions at the study area to document the ethnobotany of plants. Farmers of this region give good weightage for predictions of onset of monsoon because the choice of cropping pattern depends on that. Villagers have been using the behavior of specific birds, plants, animals, wind direction (on *Akhatrij*) as indicators of rain.

1. *Avicennia marina* (Cheriya) (Resource person: Rama Kara, Virambhai)

   Leaves are used as fodder in famine. Dried branches are used as fuel.

2. *Alhagi pseudalhagi* (Javaso) (Resource person: Virambhai)

   Plants are used as fodder during starvation condition. Whole plant is boiled in water and bathed to cure itching.

3. *Argemone mexicana* (Darudi) (Resource person: Virambhai)

   During fever, make an equal mixture of its seeds with black pepper. Then, take it twice a day for 2 days with one cup curd.

4. *Asphodelus tenuifolius* (Dungro) (Resource person: Virambhai, Rama Kara)

   During stomach ulcers, half cup leaves juice is given for 2 days.

5. *Acacia nilotica* (Desi baval, Dataniyo baval) (Resource person: Rama Kara)

   Fresh exuding gum is eaten and liked by children. Twigs are used as *datun* (traditional tooth brush).

6. *Barleria prionitis* (Kantasheriyo) (Resource person: Rama Kara)

   Paste of the whole plant is mixed with til oil (sesame oil) and heated then applied for bone fracture in cattle.

7. *Calotropis gigantea* (Aakdo) (Resource person: Jayendra Chudasama)

   A garland of the flowers is offered to Lord Hanuman. Root bark powder is given during snake bites. Salt is mixed in milky latex and dried to powder form, and applied during toothache.

8. *Pentatropis spiralis* (Hudiyo) (Resource person: Nagarjun, Janakbhai)

   Leaves are crushed and mixed with cattle feed, to increase milk yield.

9. *Pergularia daemia* (Chamardudhli) (Resource person: Nagarjun)

   At least ten flowers are taken along with table salt twice a day for treatment of cough.

10. *Tridax procumbens* (Pardeshi bhangro) (Resource person: Pola Odedra)

    Paste of leaves is applied over fresh cuts to check bleeding.

11. *Eclipta alba* (Kalobhangro) (Resource person: Pola Odedra)

    Leaf extract of *Eclipta alba* and ash of dried *Heliotropium supinum* mixed with coconut oil and applied on hairs to remove dandruff.

12. *Heliotropium supinum* (Ghediyo Okhrad) (Resource person: Nagarjun)

    Plant is used as a fodder. Leaf extract of *Eclipta alba* and ash of dried *Heliotropium supinum* mixed with coconut oil and applied on hairs to remove dandruff.

13. *Cassia occidentalis* (Kasundro) (Resource person: Pola Odedra, Nagarjun)

    Fruits considered as a good fodder. During throat infection, half spoon leaf juice is taken along with honey.

14. *Cadaba fruticosa* (Kalo katkiyo) (Resource person: Pola Odedra, Nagarjun, Janakbhai)

    Grown as fence on agricultural hedges for protection against animals and wind.

15. *Capparis decidua* (Kerdo) (Resource person: Pola Odedra)

    Unripe fruits are used to prepare pickles and ripe fruits are eaten. Grown as fencing on agricultural hedges against animals.

16. *Maerua arenaria* (Dholo Katkiyo) (Resource person: Pola Odedra, Nagarjun, Janakbhai)

    Grown as fencing on agricultural hedges against animals.

17. *Commelina benghalensis* (Shishmudiyu) (Resource person: Nagarjun)

    To get relief from swelling of eyes, leaf extract is applied over eyes two or three times a day.

18. *Bolboschoenus maritimus* (Saaj) (Resource person: Pola Odedra, Nagarjun, Janakbhai)

    Good fodder for cattle. Tubers having high starch content are consumed by purple moorhens and wild soars.

19. *Schoenoplectus littoralis* subsp. *thermalis* (Tader)

The plant is not consumed by any animal or bird. Plants are stacked in compact bundles and tied to make thatch work of the roof.

20. *Clitoria ternetea var. ternetea f. ternetea* (Garni) and *C. ternetea var. ternetea f. albiflora* (Dholi Gharni) (Resource person: Jayendra Chudasama)

    Both blue and white flowers are offered to God in temples.

21. *Medicago sativa* (Gadab) (Resource person: Rama Kara)

    Plants are grown and used as healthy nutritive fodder. Flowering twigs are tied around the marriage *mandap* as toran to decorate it in house of bride.

22. *Pithecellobium dulce* (Goras Ambli) (Resource person: Rama Kara)

    The white aril is sweet in taste and eaten fondly by people. Dried stem is used as fuel and making agricultural implements.

23. *Indigofera oblongifolia* (Jhil) (Resource person: Rama Kara)

    Twigs are used as a broom. Aerial parts are used as a fodder in famine condition.

24. *Azadirachta indica* (Limdo) (Resource person: Raju Parmar, Nagarjun, Janakbhai, Karsan Waghela, Darshan Chavda, Deudhabhai, Lakhabhai, Khimjibhai)

    If more fruit appears in tree and it remains healthy and ripen than it is sign of good season for agriculture. Twigs are used as *datun* (traditional toothbrush). Leaves are burnt to repel mosquitoes. To confirm whether the snake that had bitten the person was poisonous or not this plant is used, leaves are chewed by the person and if it is tasteless than the snake is declared to be poisonous.

25. *Prosopis juliflora* (Gando baval) (Resource person: Raju Parmar, Nagarjun, Janakbhai, Karsan Waghela, Darshan Chavda, Deudhabhai, Lakhabhai, Khimjibhai)

    Pods are very useful as cattle fodder in adverse condition. Dried branches are used as fuel. Dry branching is used to prepare fencing surrounding the cropland and also act as a live fence. The wood is used for coal.

26. *Nymphaea pubescens* (Nilkamal) (Resource person: Raju Parmar, Nagarjun, Janakbhai, Karsan, Darshan Chavda, Deudhabhai, Khimjibhai)

    Beautiful flowers are offered to God in temples. Seeds are edible and used in various religious ceremonies.

27. *Cynodon dactylon* (Dhrokad) (Resource person: Nagarjun, Janakbhai)

Whole plant is used as fodder. Internodes are chewed.

28. *Vernonia cinerea* (Sedradi)

Leaf juice is applied on cuts and wounds to check bleeding and as an antiseptic also. Decoction of whole plant is given in the morning in empty stomach to cure fever.

29. *Xanthium strumarium* (Gaadariyu) (Resource person: Rama Kara)

During earache apply leaf extract two to three drops in ear.

30. *Euphorbia neriifolia* (Katara) (Resource person: Rama Kara)

Leaves are sour in taste and rich in Vitamin C content, and are eaten before 12 pm. It is believed that if there good foliage observed it is sign of good rains.

4.4 THREATENED SPECIES AND THEIRCONSERVATION SIGNIFICANCE

The below table (Table 11) shows that most of the species collected from both the wetland sare come under not evaluated or least concern criteria. *Commiphora wightii* is Critically Endangered as per A2cd (ver. 3.1). *Hyphaene dichotoma* is at Lower Risk or Near Threatened as per *ver*. 3.1;38 species are Least Concern as per *ver.* 3.1.1;22 species are Not Evaluatedas per *ver*. 3.1.The distribution of *Commiphora wightii* is restricted to India and Pakistan. *Commiphora wightii* and *Hyphaene dichotoma* are two rare species so their *in situ* conservation is needed.

Table 11: IUCN status of the Species

Sn	Botanical name	IUCN status
1.	*Commiphora wightii*	CR A2cd (ver. 3.1)
		
2.	*Hyphaene dichotoma*	LR/NT (ver 2.3)
		
LEAST CONCERN		
3.	*Alternanthera sessilis*	LC (ver. 3.1)
4.	*Ammannia baccifera*	LC (ver. 3.1)
5.	*Avicennia marina*	LC (ver. 3.1)
6.	*Bacopa monnieri*	LC (ver. 3.1)
7.	*Bulboschoenus maritimus* ssp. *affinis*	LC (ver. 3.1)
8.	*Ceratopteris thalictroides*	LC (ver. 3.1)
9.	*Ceriops tagal*	LC (ver. 3.1)
10.	*Commelina benghalensis*	LC (ver. 3.1)
11.	*Cressa cretica*	LC (ver. 3.1)
12.	*Cyperus arenarius*	LC (ver. 3.1)
13.	*Cyperus esculentus*	LC (ver. 3.1)
14.	*Dopatrium junceum*	LC (ver. 3.1)
15.	*Echinochloa colona*	LC (ver. 3.1)
16.	*Eleocharis geniculata*	LC (ver. 3.1)

Sn	Botanical name	IUCN status
17.	*Fimbristylis ferruginea*	LC (ver. 3.1)
18.	*Grangea maderaspatana*	LC (ver. 3.1)
19.	*Hydrilla verticillata*	LC (ver. 3.1)
20.	*Hygrophila schulli*	LC (ver. 3.1)
21.	*Indigofera oblongifolia*	LC (ver. 3.1)
22.	*Ipomoea aquatic*	LC (ver. 3.1)
23.	*Lemna gibba*	LC (ver. 3.1)
24.	*Limnophyton obtusifolium*	LC (ver. 3.1)
25.	*Marsilea quadrifolia*	LC (ver. 3.1)
26.	*Merremia emarginata*	LC (ver. 3.1)
27.	*Najas marina*	LC (ver. 3.1)
28.	*Nymphaea pubescens*	LC (ver. 3.1)
29.	*Nymphaea rubra*	LC (ver. 3.1)
30.	*Ottelia alismoides*	LC (ver. 3.1)
31.	*Paspalidium geminatum*	LC (ver. 3.1)
32.	*Paspalum vaginatum*	LC (ver. 3.1)
33.	*Phragmites karka*	LC (ver. 3.1)
34.	*Phyla nodiflora*	LC (ver. 3.1)
35.	*Polygonum plebeium*	LC (ver. 3.1)
36.	*Rhizophora mucronata*	LC (ver. 3.1)
37.	*Schoenoplectus subulatus*	LC (ver. 3.1)
38.	*Sesbania bispinosa*	LC (ver. 3.1)
39.	*Stuckenia pectinata*	LC (ver. 3.1)
40.	*Typha angustifolia*	LC (ver. 3.1)
41.	*Vallisneria natans*	LC (ver. 3.1)
		
Data Defficient		
42.	*Eclipta prostrata*	DD (ver. 3.1)

Sn	Botanical name	IUCN status
		
NOT EVALUATED		
43.	*Abutilon indicum*	NE
44.	*Abutilon ramosum*	NE
45.	*Acacia nilotica*	NE
46.	*Achyranthes aspera*	NE
47.	*Aeluropus lagopoides*	NE
48.	*Alhagi maurorum*	NE
49.	*Aloe vera*	NE
50.	*Alysicarpus longifolia*	NE
51.	*Argemone Mexicana*	NE
52.	*Aristida adscensionis*	NE
53.	*Aristolochia bracteata*	NE
54.	*Arthrocnemum indicum*	NE
55.	*Asphodelus tenuifolius*	NE
56.	*Atriplex stocksii*	NE
57.	*Azadirachta indica*	NE
58.	*Barleria prionitis*	NE
59.	*Bergia odorata*	NE
60.	*Blepharis integrifolia*	NE
61.	*Boerhavia chinensis*	NE
62.	*Cadaba fruticosa*	NE
63.	*Calotropis gigantean*	NE
64.	*Calotropis procera*	NE
65.	*Capparis deciduas*	NE
66.	*Cardiospermum halicacabum*	NE
67.	*Celosia argentea*	NE
68.	*Cenchrus ciliaris*	NE
69.	*Chenopodium album*	NE
70.	*Chloris barbata*	NE

Sn	Botanical name	IUCN status
71.	*Chrozophora plicata*	NE
72.	*Chrozophora rottleri*	NE
73.	*Clerodendron serratum*	NE
74.	*Clitoria ternetea* var. *ternetea* f.*albiflora*	NE
75.	*Clitoria ternetea* var. *ternetea* f.*ternetea*	NE
76.	*Coccinia grandis*	NE
77.	*Cocculus hirsutus*	NE
78.	*Coldenia procumbens*	NE
79.	*Convolvulus microphyllus*	NE
80.	*Corchorus aestuans*	NE
81.	*Corchorus depressus*	NE
82.	*Corchorus olitorius*	NE
83.	*Corchorus tridens*	NE
84.	*Corchorus trilocularis*	NE
85.	*Cordia dichotoma*	NE
86.	*Cordia sinensis*	NE
87.	*Ctenolepis cerasiformis*	NE
88.	*Cucumis maderaspatanus*	NE
89.	*Cucumis prophetarum*	NE
90.	*Cynodon dactylon*	NE
91.	*Dactyloctenium aegyptium*	NE
92.	*Datura metel*	NE
93.	*Dinebra retroflexa*	NE
94.	*Dyerophytum indicum*	NE
95.	*Echinops echinatus*	NE
96.	*Eichhornia crassipes*	NE
97.	*Elytraria acaulis*	NE
98.	*Enicostema axillare*	NE
99.	*Eragrostis ciliaris*	NE
100.	*Euphorbia perfoliata*	NE
101.	*Euphorbia prostrate*	NE

Sn	Botanical name	IUCN status
102.	*Fagonia schweinfurthii*	NE
103.	*Glinus lotoides*	NE
104.	*Gossypium stocksii*	NE
105.	*Grewia tenax*	NE
106.	*Halopyrum mucronatum*	NE
107.	*Heliotropium bacciferum*	NE
108.	*Heliotropium curassavicum*	NE
109.	*Heliotropium supinum*	NE
110.	*Indigofera cordifolia*	NE
111.	*Juncus maritimus*	NE
112.	*Justicia procumbens*	NE
113.	*Lantana camara* ssp. *Aculeate*	NE
114.	*Launaea procumbens*	NE
115.	*Leucaena leucocephala*	NE
116.	*Lotus garcinii*	NE
117.	*Maerua oblongifolia*	NE
118.	*Medicago sativa*	NE
119.	*Mollugo pentaphylla*	NE
120.	*Nothosaerva brachiata*	NE
121.	*Ocimum americanum*	NE
122.	*Oxystelma esculentum*	NE
123.	*Parkinsonia aculeate*	NE
124.	*Parthenium hysterophorus*	NE
125.	*Passiflora foetida*	NE
126.	*Pavonia ceratocarpa*	NE
127.	*Pentatropis capensis*	NE
128.	*Pergularia daemia*	NE
129.	*Peristrophe bicalyculata*	NE
130.	*Phoenix sylvestris*	NE
131.	*Physalis minima*	NE
132.	*Pithecellobium dulce*	NE

Sn	Botanical name	IUCN status
133.	*Pluchea lanceolata*	NE
134.	*Polycarpaea spicata*	NE
135.	*Portulaca quadrifida*	NE
136.	*Prosopis juliflora*	NE
137.	*Pulicaria angustifolia*	NE
138.	*Rungia elegans*	NE
139.	*Rungia repens*	NE
140.	*Salicornia brachiata*	NE
141.	*Salvadora persica*	NE
142.	*Senna auriculata*	NE
143.	*Senna occidentalis*	NE
144.	*Sesbania sesban*	NE
145.	*Sesuvium portulacastrum*	NE
146.	*Setaria pumila*	NE
147.	*Sida mysorensis*	NE
148.	*Solanum virginianum*	NE
149.	*Sporobolus virginicus*	NE
150.	*Stemodia viscose*	NE
151.	*Suaeda fruticosa*	NE
152.	*Suaeda nudiflora*	NE
153.	*Tamarix indica*	NE
154.	*Tamarix stricta*	NE
155.	*Taverniera cuneifolia*	NE
156.	*Tinospora cordifolia*	NE
157.	*Tridax procumbens*	NE
158.	*Urochondra setulosa*	NE
159.	*Verbascum chinense*	NE
160.	*Vernonia cinerea*	NE
161.	*Wattakaka volubilis*	NE
162.	*Xanthium indicum*	NE
163.	*Ziziphus mauritiana*	NE

Sn	Botanical name	IUCN status
164.	*Ziziphus nummularia*	NE

4.5 INVASIVE SPECIES

As per the Global Invasive Species Database (GISD), Invasive Species Specialist Group of the IUCN Species Survival Commission (http://www.issg.org/database), *Prosopis juliflora, Eichhornia crassipes, Hydrilla verticillata, Ipomoea aquatica* are the invasive species of Gosabara wetland complex.

Prosopis juliflora is the main invasive species and has occupied the maximum area of Khijadiya bird sanctuary.

1. *Prosopis juliflora*

Prosopis is the main invasive species of both the wetlands especially in Khijadiya where it covers the maximum area of the sanctuary.*Prosopis* species are amongst a range of invasive woody plants being eradicated due to their noted effect in exploiting soil water and lowering water tables. *Prosopis* are phraetophytic and are known to possess very deep roots which will use subterranean water when no surface water is available. In India, *Prosopis* has been blamed by large-scale farmers for the lowering of water tables, while some researchers suggest that this is due to the increase in the number of boreholes and the amounts of water being extracted for irrigation by these very same farmers.

Positive impacts on the environment include soil stabilization by the roots and reduced soil erosion from windbreaks and within plantations, reduced salinity and alkalinity, and improved soil fertility and soil physical characteristics. Also the presence of *P. juliflora* as a readily available source of fuel has drastically reduced the previous over-exploitation and illegal cutting in protected reserves.

Observing the GIS data of Khijadiya for the month of November 2015 and April 2016, there is a vast change in the *P. juliflora* canopy. The *P. juliflora* has been reduced from 4.8 sq. km to 2.3 sq. km. *Prosopis* is an invasive vigorous plant which is able to establish itself in post monsoon if there is an inadequate rain. However, if the rains are adequate the plants get drained in the water for a period of 3-4 months and are not able to establish

themselves. In addition during post monsoon period the water pockets becomes grazing land. The Pods (seeds) of *Prosopis* swallowed by the goats and cattles which breaks the seed dormancy of the seed and with the first rains the plants germinates and increases its horizon in the aquatic pocket. In Plate 6 it is clearly seen invasion of *Prosopis* by grren canopied and the spots marked with yellow are the areas from where the prosopis was removed by the Forest department for the storage of water in the next rains. In Gosabara there is no noticible change in the *Prosopis* cover during this period.

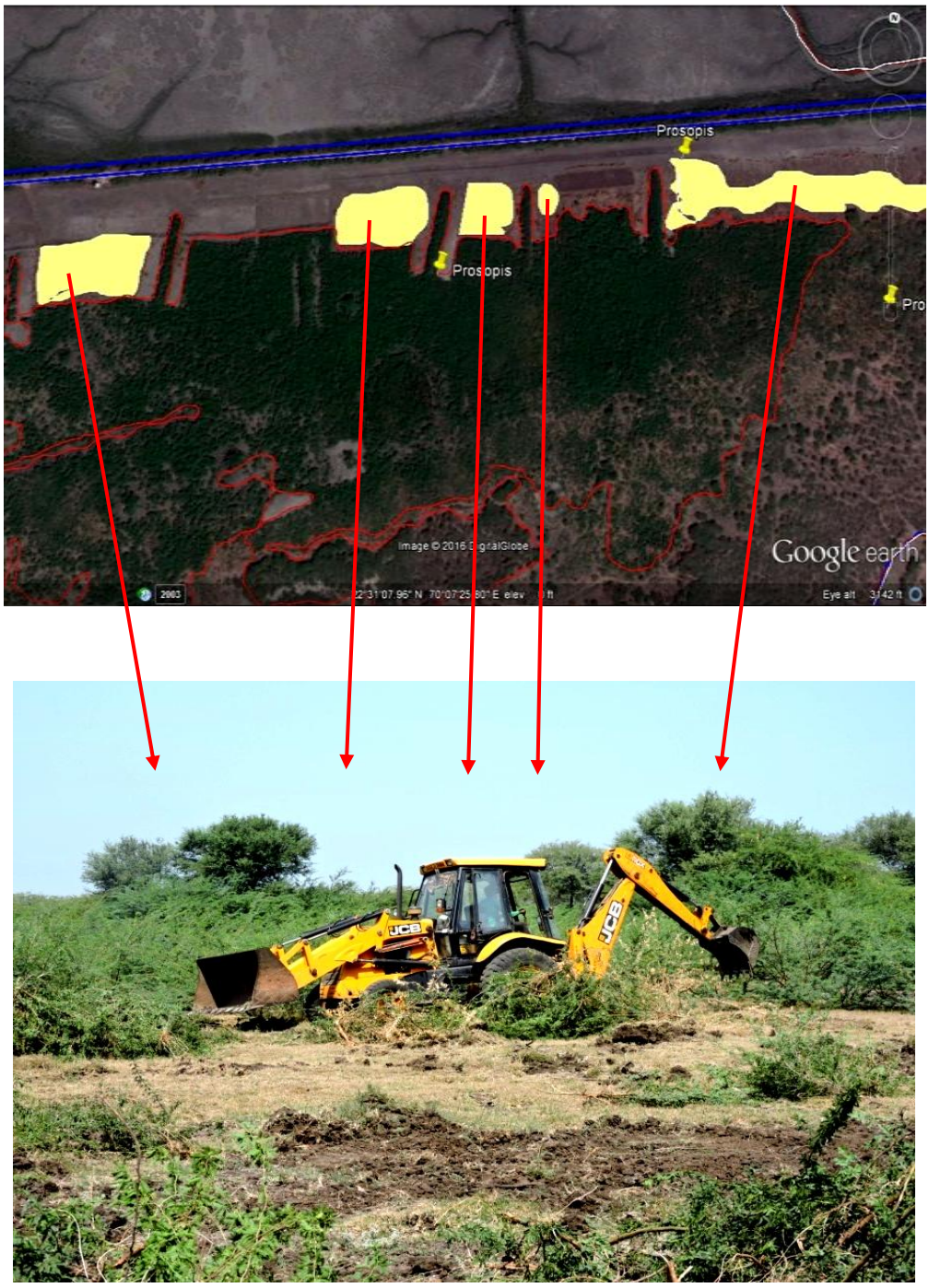


Plate 6: *Prosopis* removal from Khijadiya Sanctuary

2. *Eichhornia crassipes*

E. crassipes, a native of South America, is a major freshwater weed in most of the frost-free regions of the world and is generally regarded as the most trouble some aquatic plant (Holm *et al*., 1997). It has been widely planted as water ornamental around the world because of its striking flowers. Wherever it has encountered suitable environmental conditions it has spread with phenomenal rapidity to form vast monotypic stands in lakes, rivers and rice paddy fields. Then it adversely affects human activities (fishing, water transport) and biodiversity. It is impossible to eradicate, and often only an integrated management strategy, inclusive of biological control, can provide a long-term solution to this pest.

Plate 7: *Eichhornia* invasion in Gosabara

Once it proliferates in a water body, *E. crassipes* dramatically alters the ecosystem and often results in environmental degradation and a reduction in bio-diversity. A number of authors note that in many water bodies and wetland areas, the encroachment of water hyacinth has reduced or eliminated natural vegetation (Terry, 1996; Kumar and Rohatgi, 1999). The plant may negatively impact some native species of invertebrates, fish, birds and plants. Presently a patch of *E. crassipes* is seen in the small pocket of Vanana creek of Gosabara. Though it is in fresh water pockets on the extreme south of the creek .It may gradually spread towards the wetern parts and it may lead to eutrophication (Plate 7.)

4.6 DOCUMENTATION OF ENGLISH AND LOCAL NAME

Table12 gives information on local names of 128 plants and English names of 148 plants. The local names prvided here are the names used by the local people of the study area.

Table 12: English and Local name of the species

Sn	Botanical name	English name	Local name
1.	*Abutilon indicum*	Indian Mallow	Khapat
2.	*Abutilon ramosum*	Indian Mallow	Dholi khapat
3.	*Acacia nilotica*	Gum arabic tree, Egyptian thorn	Dataniyo Baval
4.	*Achyranthes aspera*	Prickly Chaff Flower, Devil's Horsewhip	Aghedo
5.	*Aeluropus lagopoides*	Mangroove Grass, Rabbit-Foot	Khariyu
6.	*Alhagi pseudalhagi*	Camel thorn	Javaso
7.	*Aloe vera*	Aloe, Burn plant	Kuvar
8.	*Alternanthera sessilis*	Sessile Joyweed, Dwarf copperleaf	Jal jambvo
9.	*Alysicarpus longifolia*	-	Ubho samervo
10.	*Ammannia baccifera*	Blistering Ammania	Jal agiyo
11.	*Argemone mexicana*	Mexican prickly poppy	Darudi
12.	*Aristida adscensionis*	Six-weeks three-awn	Uth lampdo
13.	*Aristolochia bracteata*	Dutchman's pipe and Pipevine	Kidamari
14.	*Arthrocnemum indicum*	-	Machur, Bholdo
15.	*Asphodelus tenuifolius*	Onionweed	Dungro
16.	*Atriplex stocksii*	Saltbush	Adbau palak

Sn	Botanical name	English name	Local name
17.	*Avicennia marina*	Grey mangroove, White mangroove	Tavariya, Cheriya
18.	*Azadirachta indica*	Margossa, Indian Lilac	Limdo
19.	*Bacopa monnieri*	Indian Pennywort, Water Hyssop	Bam, Jal nevri
20.	*Barleria prionitis*	Porcupine flower	Kantasheriyo
21.	*Bergia odorata*	-	Lavadiyu
22.	*Blepharis integrifolia*	-	Utingan
23.	*Boerhavia chinensis*	Spreading Hogweed	Satodi
24.	*Bulboschoenus maritimus*	Sea clubrush	Saaj
25.	*Cadaba fruticosa*	Capper Brush	Teliyo Hemkand
26.	*Calotropis gigantean*	Crown flower	Moto Aakdo
27.	*Calotropis procera*	Milkweed	Aakdo
28.	*Capparis decidua*	Caper berry	Kerdo
29.	*Cardiospermum halicacabum*	Balloon plant, Love in a puff	Kagdodiyo, Karodiyo
30.	*Cenchrus ciliaris*	African foxtail grass	-
31.	*Ceratopteris thalictroides*	Floating water fern	-
32.	*Celosia argentea*	Plumed cockscomb, Silver cock's comb	Lampdi
33.	*Ceriops tagal*	Tagal Mangroove	-
34.	*Chenopodium album*	White goosefoot, Pigweed	-
35.	*Chloris barbata*	Swollen Finger Grass, Airport grass	Mindadiyu Ghas
36.	*Chrozophora plicata*	Turnsole	Betho okhrad
37.	*Chrozophora rottleri*	Dyer's Litmus	Suryavirt, Kalo okhrad
38.	*Clerodendron serratum*	Beetle Killer	Arni
39.	*Clitoria ternetea* var. *ternetea* f. *albiflora*	Butterfly pea	Dholi Gharni
40.	*Clitoria ternetea* var. *ternetea* f. *ternetea*	Blue pea	Garni
41.	*Coccinia grandis*	West Indian gherkin	Kadvi, Ghiloda

Sn	Botanical name	English name	Local name
42.	*Cocculus hirsutus*	Broom Creeper, Ink berry	Vevdi
43.	*Coldenia procumbens*	Creeping Coldenia	Basariyo Okhrad
44.	*Commelina benghalensis*	Benghal dayflower, tropical spiderwort	Shishmudiyu
45.	*Commiphora wightii*	Indian bdellium-tree	Gugal
46.	*Convolvulus microphyllus*	Bindweed, Brain tonic	Shankhavali
47.	*Corchorus aestuans*	East Indian Mallow	Chunch, Jiteli
48.	*Corchorus depressus*	Corchorus	Bahufali, Jhinki chunch
49.	*Corchorus ollitorius*	Wild jute, Tossa jute	Chuchdo, Moti chunch
50.	*Corchorus tridens*	Horn-fruited jute	Kadvi chunch
51.	*Corchorus trilocularis*	African jute	Lambi chunch
52.	*Cordia dichotoma*	Indian cherry, Clammy cherry, Fragrant manjack	Gunda
53.	*Cordia sinensis*	Grey leaved saucerberry	Gundi
54.	*Cressa cretica*	Littoral bind weed	Paliyo, Pariyo
55.	*Ctenolepsis cerasiformis*	-	-
56.	*Cucumis maderaspatanus*	Madras pea pumpkin, Rough bryony	Chanak chibdi
57.	*Cucumis prophetarum*	Globe cucumber	Kantada indramana
58.	*Cynodon dactylon*	Dog's toothgrass, Bahama grass, Devil's grass, Couch grass	Dhrokad, Dhro
59.	*Cyperus arenarius*	Nutsedge	-
60.	*Cyperus esculentus*	Chufa sedge, Nut grass, Yellow nutsedge, Tiger Nut sedge, Earth almond	-
61.	*Dactyloctenium aegyptium*	Egyptian crowfoot grass	-
62.	*Datura metel*	Devil's trumpet	Daturo
63.	*Dinebra retroflexa*	Viper grass	-
64.	*Dopatrium junceum*	Rushlike Dopatrium	-
65.	*Dyerophytum indicum*	-	Pavi

Sn	Botanical name	English name	Local name
66.	*Echinochloa colona*	Jungle rice, Awnless barnyard grass	-
67.	*Echinops echinatus*	Indian Globe Thistle	Untkato
68.	*Eclipta prostrata*	False daisy	Kalobhangro
69.	*Eichhornia crassipes*	Water Hyacinth	-
70.	*Eleocharis geniculata*	Bentspikerush, Canada spikesedge	-
71.	*Elytraria acaulis*	Asian Scalystem	-
72.	*Enicostema axillare*	Indian Gentian	Mamejvo
73.	*Eragrostis ciliaris*	Lovegrass, Feather lovegrass	Marmar ghas
74.	*Euphorbia perfoliata*	-	-
75.	*Euphorbia prostrata*	Prostrate sandmat	-
76.	*Fagonia schweinfurthii*	Khorasan thorn, Virgin's Mantle, Virgon's Mantlem	Dhamaso
77.	*Fimbristylis ferruginea*	Rusty sedge, West Indian fimbry	-
78.	*Glinus lotoides*	Lotus sweet juice	Mitho Okhrad
79.	*Gossypium stocksii*	Wild Cotton tree	Kapas, Hirvani
80.	*Grangea maderaspatana*	Madras Carpet	Jhinki mundi
81.	*Grewia tenax*	White cross berry	Gangeti, Bajothiyu
82.	*Halopyrum mucronatum*	-	Dariyai Kasado
83.	*Heliotropium bacciferum*	Turnsole	-
84.	*Heliotropium curassavicum*	-	Hathisundho
85.	*Heliotropium supinum*	Dwarf Heliotrope	Ghediyo Okhrad
86.	*Hydrilla verticillata*	Esthwaite Waterweed	-
87.	*Hygrophila schulli*	Temple plant, Marsh Barbel	Sarpat
88.	*Hyphaene dichotomoma*	Doum palm, Gingerbread tree	Ravantaad, Hokataad
89.	*Indigofera cordifolia*	Heart-Leaf Indigo	Dadiyo
90.	*Indigofera oblongifolia*	Common Indigo	Jhil
91.	*Ipomoea aquatica*	Chinese spinach, Chinese Watercress	Nala ni bhaji
92.	*Juncus maritimus*	Seaside rush	-

Sn	Botanical name	English name	Local name
93.	*Justicia procumbens*	Water willow, Shrimp plant	Khetrau Khadsaliyo
94.	*Lantana camara* ssp. *aculeata*	Wild-sage, Red-sage	Abhagan
95.	*Launaea procumbens*	Creeping Launaea	Bhopatri
96.	*Lemna gibba*	Swollen duckweed	-
97.	*Leucaena leucocephala*	White leadtree, Jumbay, River tamarind	Su babul
98.	*Limnophyton obtusifolium*	Blunt Arrowhead	-
99.	*Lotus garcinii*	Bird's-foot trefoil	Moto Bhakho
100.	*Maerua oblongifolia*	Desert Maerua	Dudhiyo Hemkand
101.	*Marsilea quadrifolia*	Four leaf clover	-
102.	*Medicago sativa*	Alfalfa	Gadab
103.	*Merremia emarginata*	Kidney leaf morning glory	Undarkani
104.	*Mollugo pentaphylla*	Five Leaved Carpetweed	-
105.	*Najas marina*	Spiny naiad	-
106.	*Nothosaerva brachiata*	Minute Amaranth	-
107.	*Nymphaea pubescens*	Hairy water lily	Dholo kamal
108.	*Nymphaea rubra*	Pink water-lily	Lal kamal
109.	*Ocimum americanum*	Great basil, Saint-Joseph's-wort	Ram tulsi
110.	*Ottelia alismoides*	Duck-Lettuce, Waterplantain Ottelia	-
111.	*Oxystelma esculentum*	Rosy Milkweed Vine	Narot, Jaldudhi
112.	*Parkinsonia aculeata*	Jerusalem thorn, Jelly bean tree	Ram baval, Til baval
113.	*Parthenium hysterophorus*	Congress weed , Carrot grass	-
114.	*Paspalidium geminatum*	Egyptian panicgrass	-
115.	*Paspalum vaginatum*	Cow grass, Rice grass, Ditch millet	Jungli Kodri
116.	*Passiflora foetida*	Wild maracuja, Bush passion fruit, Stinking passionflower	Krishna kamal
117.	*Pavonia ceratocarpa*	Sour swamp mallow	Khatichaas
118.	*Pentatropis capensis*	-	Hudiyo

Sn	Botanical name	English name	Local name
119.	*Pergularia daemia*	Trellis-vine	Chamardudhli
120.	*Peristrophe bicalyculata*	Panicled Foldwing	Kali Aghedi
121.	*Phoenix sylvestris*	Silver Date Palm	Khajuri
122.	*Phragmites karka*	Tall reed	Nayri, Nali
123.	*Phyla nodiflora*	Turkey tangle fogfruit	Ratvelio
124.	*Physalis minima*	Native gooseberry, Wild cape gooseberry, Pygmy groundcherry	Parpopti, Popti
125.	*Pithecellobium dulce*	Monkeypod	Goras Ambli
126.	*Pluchea lanceolata*	Rasna	Rashna
127.	*Polycarpaea spicata*	-	Vajradanti
128.	*Polygonum plebeium*	Common knotweed	Jhinko okhrad
129.	*Portulaca quadrifida*	Chickenweed	Luni
130.	*Prosopis juliflora*	Mesquite	Gando baval
131.	*Pulicaria angustifolia*	-	Shishoriya
132.	*Rhizophora mucronata*	Loop-root mangroove, Red mangroove, Asiatic mangroove	-
133.	*Rungia elegans*	-	Dungri Khadsaliyo
134.	*Rungia repens*	Creeping Rungia	Moto Khadsaliyo
135.	*Salicornia brachiata*	Slender glasswort	Machul
136.	*Salvadora persica*	Arak, Meswak,Peelu, Toothbrush tree	Jaar, Piludi
137.	*Schoenoplectus subulatus*	Common Club-rush	Tader
138.	*Senna auriculata*	Tanner's Cassia	Aavad
139.	*Senna occidentalis*	Coffee Senna, Stinking Weed	Kasundro
140.	*Sesbania bispinosa*	Prickly Sesban	Ikad
141.	*Sesbania sesban*	Common sesban, Egyptian rattlepod, Egyptian riverhemp	Jayanti
142.	*Sesuvium portulacastrum*	Shoreline seapurslane	-
143.	*Setaria pumila*	Yellow foxtail, Pigeon grass, Cattail grass	Kalot

Sn	Botanical name	English name	Local name
144.	*Sida mysorensis*	Mysore fanpetals	-
145.	*Solanum virginianum*	Thorny Nightshade, Yellow Berried Nightshade	Bhoy ringani
146.	*Sporobolus virginicus*	Seashore dropseed	-
147.	*Stemodia viscosa*	Sticky Blue Rod	Nukachuni
148.	*Stuckenia pectinata*	Sago pondweed	-
149.	*Suaeda fruticosa*	Shrubby Seablite	Moras
150.	*Suaeda nudiflora*	-	Lano
151.	*Tamarix indica*	Salt cedar	Prans, Jhav
152.	*Tamarix stricta*	-	-
153.	*Taverniera cuneifolia*	East-indian Moneywort	Jethimadh
154.	*Tinospora cordifolia*	Heart-leaved moonseed	Gado
155.	*Tridax procumbens*	Mexican Daisy, Coat Buttons	Pardeshi bhangro
156.	*Typha angustifolia*	Narrowleaf cattail	Gha bajariyu
157.	*Urochondra setulosa*	-	-
158.	*Vallisneria natans*	Eelgrass, Tape grass	Jal sarpoliya
159.	*Verbascum chinense*	Common mullein	Kalhar
160.	*Vernonia cinerea*	Ash colored fleabane	Sahdevi
161.	*Wattakaka volubilis*	Sneeze Wort, Cotton milk plant	Moti dodi
162.	*Xanthium indicum*	Rough cocklebur	Gaadariyu
163.	*Zizyphusmauritiana*	Chinese date, Indian plum, Regi pandu, Indian jujube	Bordi
164.	*Zizyphus nummularia*	Wild jujube	Chaniya bor, Adbau bordi

4.9 KEY SPECIES INTERACTIONS AND ECOLOGICAL SIGNIFICANCE

1. *Ceratopteris thalictroides*

This species forms one of the important constituents of floating vegetation generally in fresh water expanses and aids in providing food and shelter to the mosquito larvae. It propagates not only by its spores which when burst out spread over in tanks and when

stranded in mud develop under suitable conditions into new plants. Vegetative reproduction takes place by means of buds borne on frond.

2. *Hydrilla verticillata*

It grows both from seed and from the detached stolons and also from the winter buds. The male flowers get detached and rise to the surface. They float and may ultimately thus reach the female organs. It is one of the most dominant species of the Hydrocharid formation. It spreads rapidly and frequently chokes up an expanse of water, thus becoming a pest of freshwater reservoirs. The plant harbours a large number of epiphytic algae which are a favourite food for the mosquito larvre. It is harmful to the self purificatory action of water by checking the development of the microplankton.

3. *Ottelia alismoides*

This species grows along with and sometimes at about the same depth as *Vallisneria.* It is less abundant than *Vallisneria*; however, tolerates water shallower than *Vallisneria*.

4. *Vallisneria natans*

This plant tends to keep water pockets in a healthy condition by diffusion of Oxygen. It helps to sustain the microplankton flora and, therefore, self-purificatory action of water in a tank.

5. *Phragmites karka*

In Khijadiya sanctuary part-2, it is found to grow along the dried wetland periphery where they form a dense mass of pure association. It may be used as a good material for manufacture of paper.The stems of the stouter ones are used for thatching purposes. This gregarious grass provides suitable habitat for insect larvae.

6. *Ipomoea aquatica:*

The plant is frequently found floating alongthe edges of Gosabara wetland, sometimes spreads over the surface and by its long rope like stems soon forms a network of vegetation choking up the surface of water. The juice of the leaves is taken as medicine which acts as mild purgative and is supposed to purify blood.

7. *Eichhornia crassipes*

The life history of this plant under different ecological conditions indicates its exceptional vital powers. The seedlings germinate in the rains from June to July and under suitable conditions may develop into a full-fledged plant within the course of three or four months bearing flowers in September or October. Abundant vegetative growth is mainly responsible for its rapid propagation although seeds are by no means less active agent than vegetative growth in continuing its progeny. Production of seeds in nature thus further complicates the question of eradication of this pest.

Danger of economic paralysis due to the existence of this plant in huge masses in the water areas need not be emphasized, as we believe that such a stage in the history of the eradication of this pest is long over. Various methods of destroying the pest have been attempted without tangible results.

8. *Lemna gibba*

Lemnas are composed of flat little green fronds producing similar fronds of second order and have extremely reduced type of inflorescences. The nature of the fronds of Lemna has been variously interpreted but the most accepted view is that the distal end of the frond is foliar while the proximal end is axile. The fronds develop air chambers. The roots of the Lemna are the heavier part and the tips with rootcaps evidently the heaviest. The roots are supposed to maintain the equilibrium of the plants. The plants are found floating in crowded masses forming a pure association on the surface of water as a thick screen of vegetation. They appear during the rains, fructify in autumn, germinate in summer and after passing a dormant stage in winter reappear in the rains as floating mass on the surface of stagnant waters.

Lemnas purify the water by absorbing organic materials and harbouring animal life. Mosquito larvre are sometimes rare in such wetlands with surface screen of *Lemnas*. But this may be due either to dearth of accommodation for the larvae due to the plants choking up every inch of space of the surface water or to the scarcity of food materials or to the presence of the animals feeding on the larvae immediately after hatching. It has been observed that edible fishes devour Lemnas in their young stages and in consideration of the quantity eaten up by them Lemnas appear to be one of their favourite foods in their early stage of life.

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Crozophora prostrata

Heliotropium curssavicum

Heliotropium supinum

Plate 8: Dry puddle species of Khijadiya wetland

Sesuvium portulacastrum

Rhizophora mucronata

Ceriops tagal

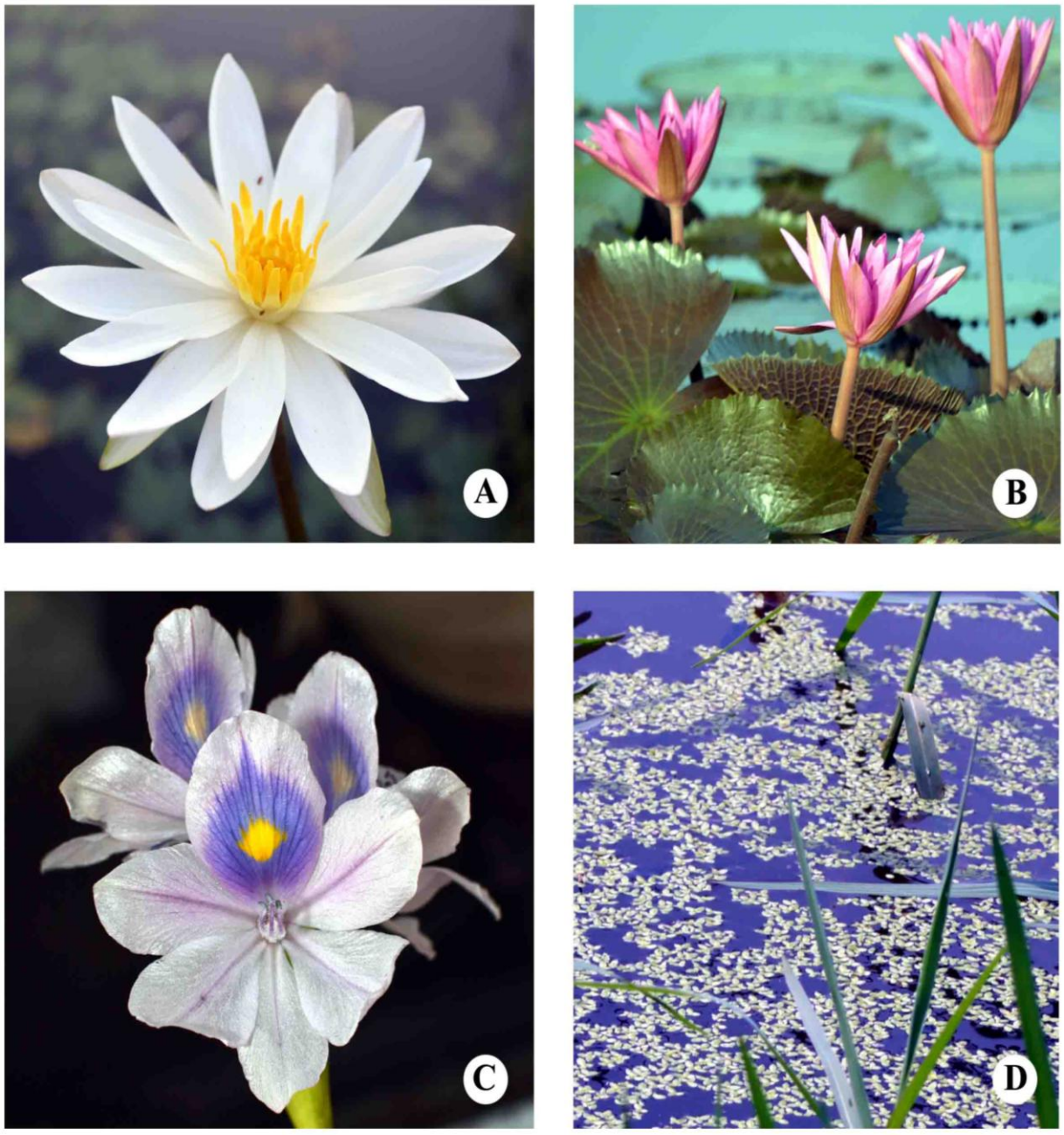
Plate 9: Mangrooves of Khijadiya

Cressa cretica

Aeluropus lagopoides

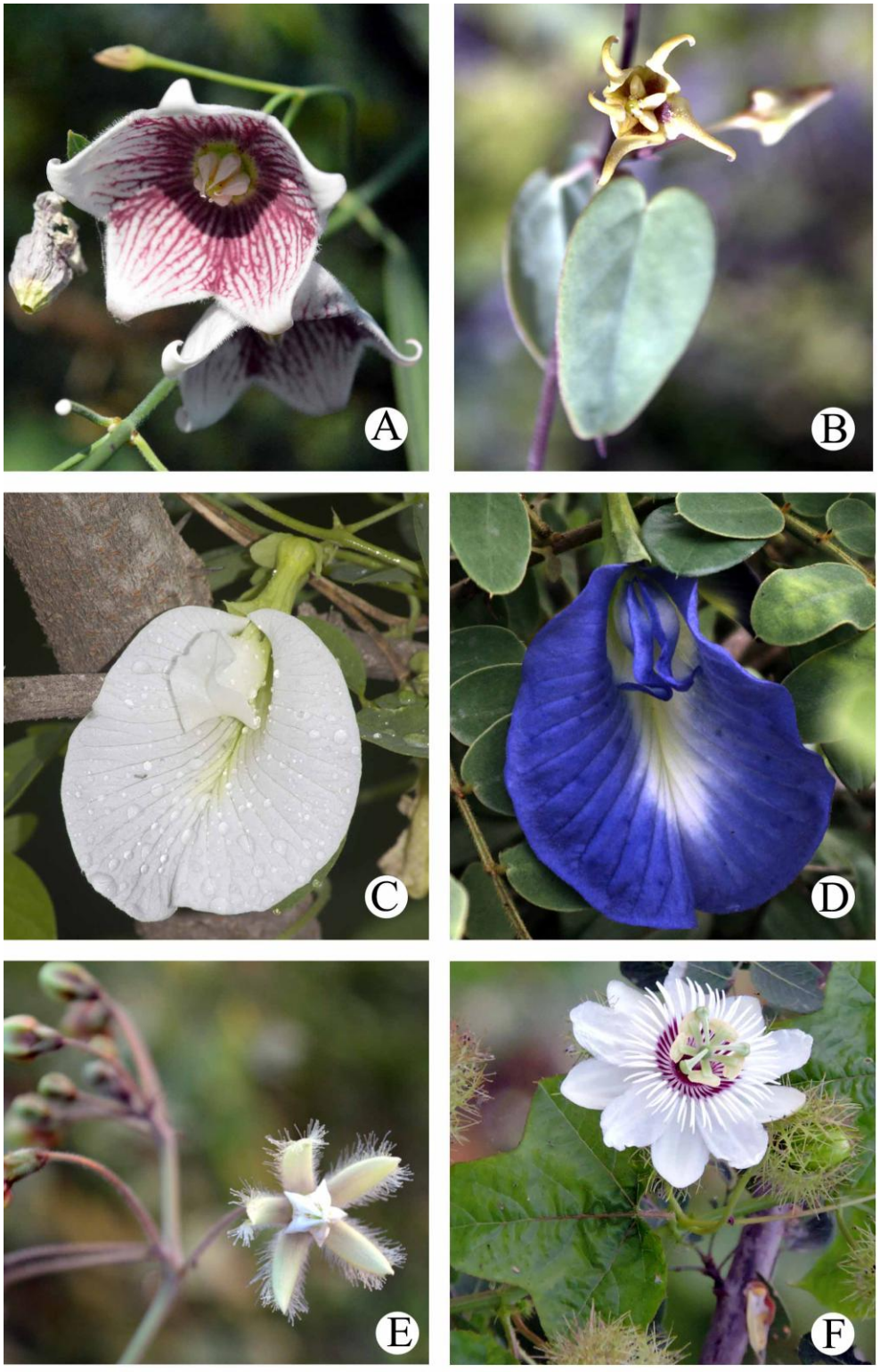
Heliotropium supinum

Plate 10: Saline ground Species



Floating aquatic plants: A. *Nympheae pubescens*, B. *Nymphaeae rubra*, C. *Eichornia crassipes*, D. *Lemna gibba*

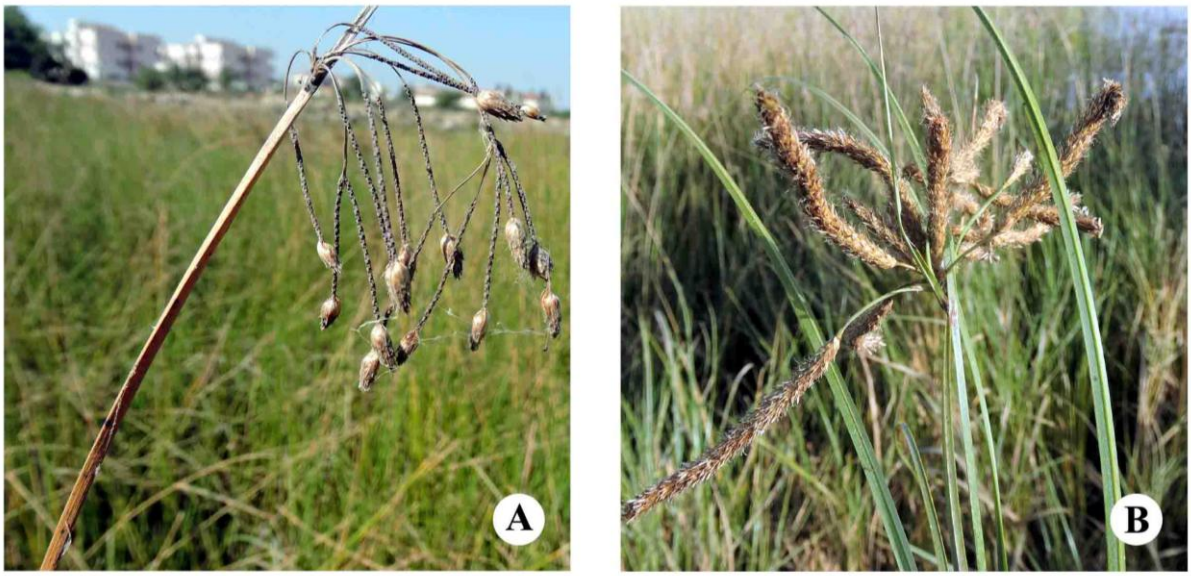
Plate 11: Floating aquatic plants



Climbers: A. *Oxystelma secamone*, B. *Pentatropis spirallis*, C. *Clitoria ternetea* var. *ternetea* f. *albiflora*, D. *C. ternetea* var. *ternetea* f. *ternetea*, E. *Pergularia daemia*, F. *Passiflora foetida*

Plate 12: Climbers

Submerged aquatic plants: A. *Hydrilla verticillata*, B. *Ottelia alisnoides*



Partially submerged aquatic plants: A. *Schoenoplectus littoralis* subsp. *thermalis*, B. *Bolboschoenus maritimus*

Plate 13: Submerged and Partially Submerged plants

About the Study

The study is part of the overall scientific and technical studies in Gujarat that the CMPA project supported towards effective and sustainable management of coastal and marine protected areas. The detailed ecological assessment focussed at documenting species diversity and population over key seasons; apart from documenting key threats to the wetlands, identification of invasive species, threatened species and an ecological analysis of the key species interactions.

The CMPA Project

The Project "Conservation and Sustainable Management of Coastal and Marine Protected Areas" (CMPA) is a project of the Indo-German technical cooperation. It is funded by the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) and implemented by the Ministry of Environment, Forests and Climate Change (MoEFCC), Government of India, and the *Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of BMUB.*

Established to support the achievement of the Aichi targets of the Convention on Biological Diversity, the Project's overall goal is to contribute to conservation and sustainable use of biodiversity in selected areas along the coast of India. Taking into consideration the economic importance of the coastal zone for large segments of the population, the Project's approach is people-centered, thus ensuring the support for conservation by those depending on coastal ecosystems.

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August 2016

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On behalf of:

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

of the Federal Republic of Germany

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Conservation and Sustainable Management of Coastal and Marine Protected Areas