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TERRESTRIAL AND MARINE ECOLOGICAL STATUS AROUND PINDARA JETTY IN DEVBHOOMI DWARKA, GUJARAT

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Abstract: For present study, the baseline study was conducted for the evaluation of the floral and faunal biodiversity of the terrestrial as well as aquatic environment of the study area, it comprises of total 5 villages falls in taluka Kalyanpur, Dist-Devbhoomi Dwarka, Gujarat. The area is ecologically sensitive and there is an urgent need for conservation of existing ecological conditions as well as corals and schedule – I species as per Wildlife (Protection) Act, 1972.

Keywords: Coral; Dwarka; Ecological sensitive; Marine; Pindara.

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INTRODUCTION

Pindara notified port limit is bordering from the other port limits of Salaiya in the east to Okha port limit in the west, to Pindara – Virpur village limits in the south and to 12 fathom (36.576 m) in the north. Out of the entire port limit only a small portion of jetty area of 0.81 hectares falls within the marine sanctuary and 3.68 hectares in eco sensitive zone which includes the existing roads leading to the Pindara Jetty. However, Pindara Jetty was notified on 18th July 1963 much earlier than notification of marine sanctuary notification in 1982 and eco sensitive zone of 1 km on 22nd August 2013. Floristic and Faunistic pattern of the area was studied based on opportunistic survey (personal observation), inquiries from the local people and forest officials and secondary data. Ecology is the study of how organisms interact with one another and with their physical environment. The distribution and abundance of organisms on Earth is shaped by biotic, living-organism-related and abiotic, nonliving or physical, factors. On the other hand, biodiversity gets used as a measure of the health of biological systems and to see whether

there is a danger that too many species become extinct.

EXPERIMENTAL

The baseline study was conducted for the evaluation of the floral and faunal biodiversity of the terrestrial as well as aquatic environment of the study area (10 Km radius from the pindara jetty area) and it comprises of total 5 villages falls in Dist-Dev Bhoomi Dwarka.

Field Study Period: The ecological survey has been conducted for one season. The ground truthing has been conducted on 22nd to 24th May 2017.

List of Villages: Pindara Village, Mota Asota village, Mahadevia village, Mevasa village and Virpur village.

Core Zone: Pindara jetty.

Buffer Zone: Around the project site in 10 Km radius.

The primary objective of survey was to describe the floral and faunal communities within the study area along with marine ecological status. The sampling plots for floral inventory were selected randomly in the suitable habitats (Anderson, 1867; Jain and Rao, 1983; Dixit, 1984; Wilson and Reeder,

2005; Kumar, 2013; Kumar *et al.*, 2013). The methodology adopted for faunal survey involve random survey, opportunistic observations, diurnal bird observation, active search for reptiles, faunal habitat assessment, active search for scats and foot prints, animal call, and review of previous studies. The aim was to set baselines in order to monitor and identify trends after the commissioning of the mineral cargo handling activity. Emphasis has been placed on presence of endemic species, threatened species if any present in the study area. The qualitative study has been carried out only. Desktop literature review was conducted to identify the representative spectrum of

threatened species, population and ecological communities listed by IUCN, WCMC, ZSI, BSI and Indian Wild life Protection Act, 1972 (Bentham and Hooker, 1862-1883; Hunter, 1879; Dixit, 1984; Ghosh *et al.*, 2004; Lushington, 1915; Wilson and Reeder, 1993; BirdLife International, 2000; BirdLife International, 2004a, b; Wilson and Reeder, 2005; BirdLife International, 2010; Kumar and Srivastava, 2012; Kumar, 2013; Kumar *et al.*, 2013; Kumar and Aggarwal, 2013a,b). The status of individual species was assessed using the revised IUCN/SSC category system (WCMC, 1988; IUCN, 1994; WCMC, 2000; IUCN, 2001, 2003, 2008, 2010).

Table 1. Mode of Data Collection and Parameters considered during the Survey

#	Aspect/s	Data	Mode of Data Collection	Parameters Monitored	Remarks
1.	Terrestrial Ecology	Primary data collection	By Field Survey Hutto <i>et al.</i> , 1986; Welsh, 1987; Thommpson <i>et al.</i> , 1989; Welsh <i>et al.</i> , 1991; Allen <i>et al.</i> , 1996; Misra, 2013.	For Floral diversity, Vegetation measurements: Tree, Shrub, Herbs, Grasses, Climbers, Cultivated plants in the study area, Floristic composition of the study area, Medicinal plants of the study area, Status of the forest, their category in the study area, Rare and endangered flora in the study area. Endemic plants in the study area. For Fauna in the study area: -Reptiles, -Amphibians, -Birds, -Fresh water fishes -Mammals, -Butterflies. Rare and Endangered fauna in the study area, Endemic fauna in the study area, Wild life and their conservation importance in the study area.	Random survey, opportunistic observations, diurnal bird observation, active search for reptiles, faunal habitat assessment, active search for microhabitat, scats, foot prints, animal call, pug marks, debarking sign, Nesting, Claws, Dung, etc. and information from local villagers.
2.		Secondary	• Dwarka SF Division.	Interpretation of	Bentham and Hooker,

				<ul style="list-style-type: none"> • Taxonomy • Nanoplanktonic Flagellates • Cnidarians • Rotifera, • Chaetognatha, • Polychaeta • Copepods • Cladocerans, • Krill • Insect Larvae • Tunicates 	Verification by authentic agency (BSI, ZSI, FRI, NIO, etc.)
4.		Secondary	Published Records	Importance, food chain, food web, dependency, indicator, etc.	Incorporation in report along with its importance
5.	Evaluation of Ecological sensitivity	Secondary	Review and Discussion	Wild life importance, Floral Endemicity, Faunal Endemicity, State of Terrestrial vegetation, State of wet land vegetation, Mangrove vegetation, Conservation importance, Legal status (National park, Wild life sanctuary, Reserve forest, Wetlands, Agricultural lands) Lakes /reservoirs/dam, Natural lakes and Swamps, Breeding ground of Migratory and Residential birds.	-

RESULTS AND DISCUSSION

Main crops of the study region are Bajra, Jowar, wheat & Tur etc. During survey natural flora of study region were found in degraded condition or under stress due to extensive industrialization. No distinct variation was observed in vegetation covered of study region. Vegetation near villages and along the road was represented by trees and shrubs. Dominant vegetation of a study area was bushes. Pindara bay is shallow in southern

stretches having depths of 0-5 m below CD upto 10 km from the shore. Further north off Positra, maximum depths of 25 m are available. An island, Azad tapu is present in the eastern side of the Pindara bay. A creek is present in the vicinity of the proposed project site. Sediment quality of the Pindara region indicates that the bed sediment is uncontaminated. The mangrove vegetation of *Avicinia marina* at proposed Jetty was observed.





Figure 1. Photos showing mangrove near Pindara jetty

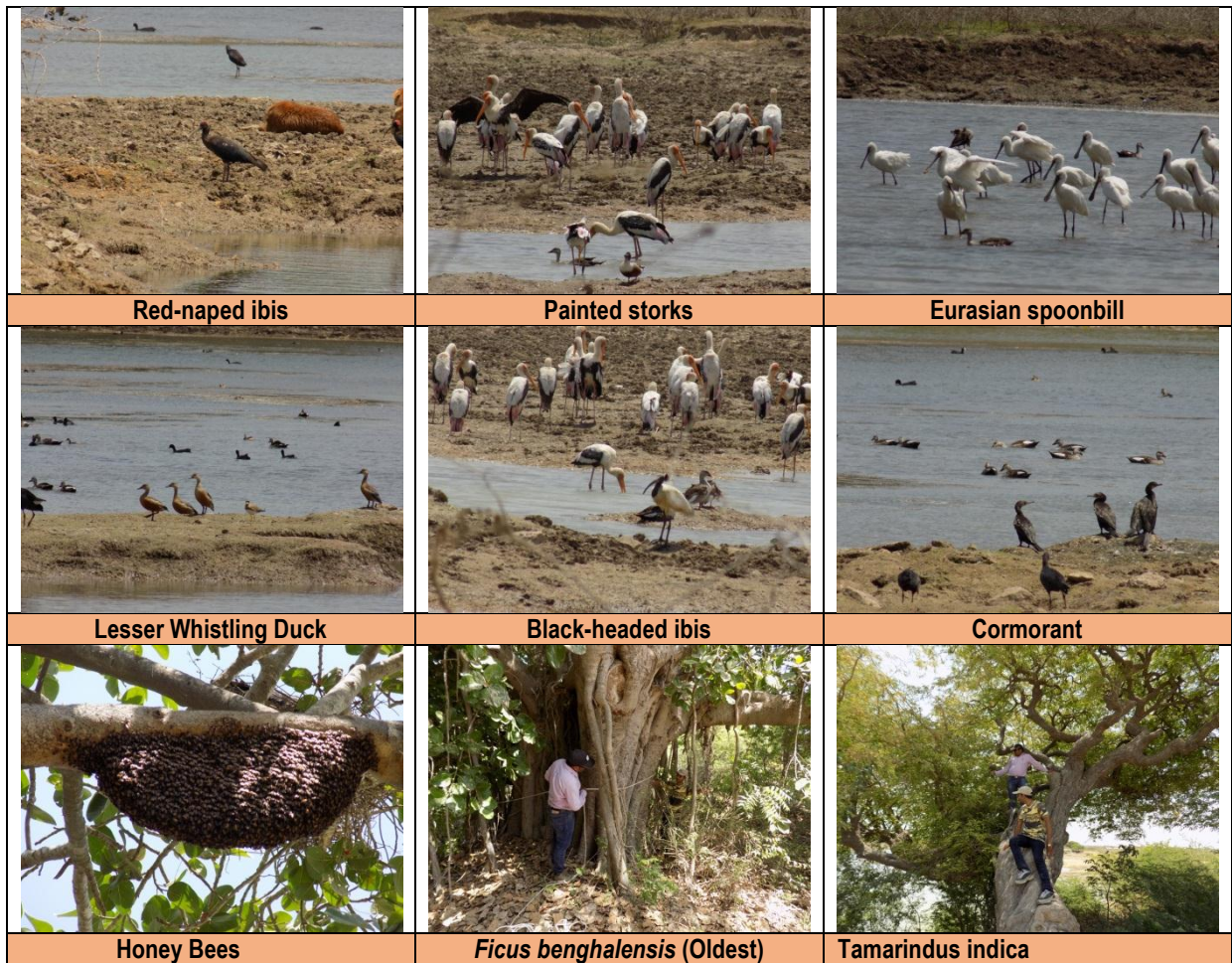


Figure 2. Floral & Faunal Biodiversity at Pindara Village

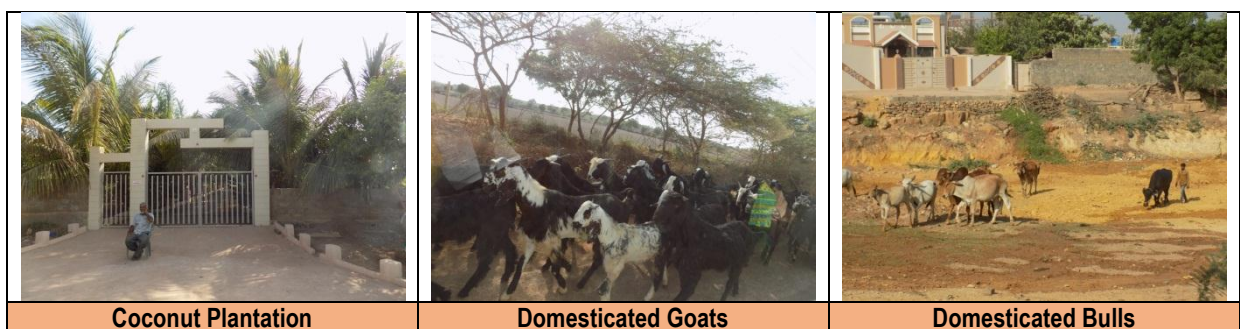


Figure 3. Photos at Virpur Village

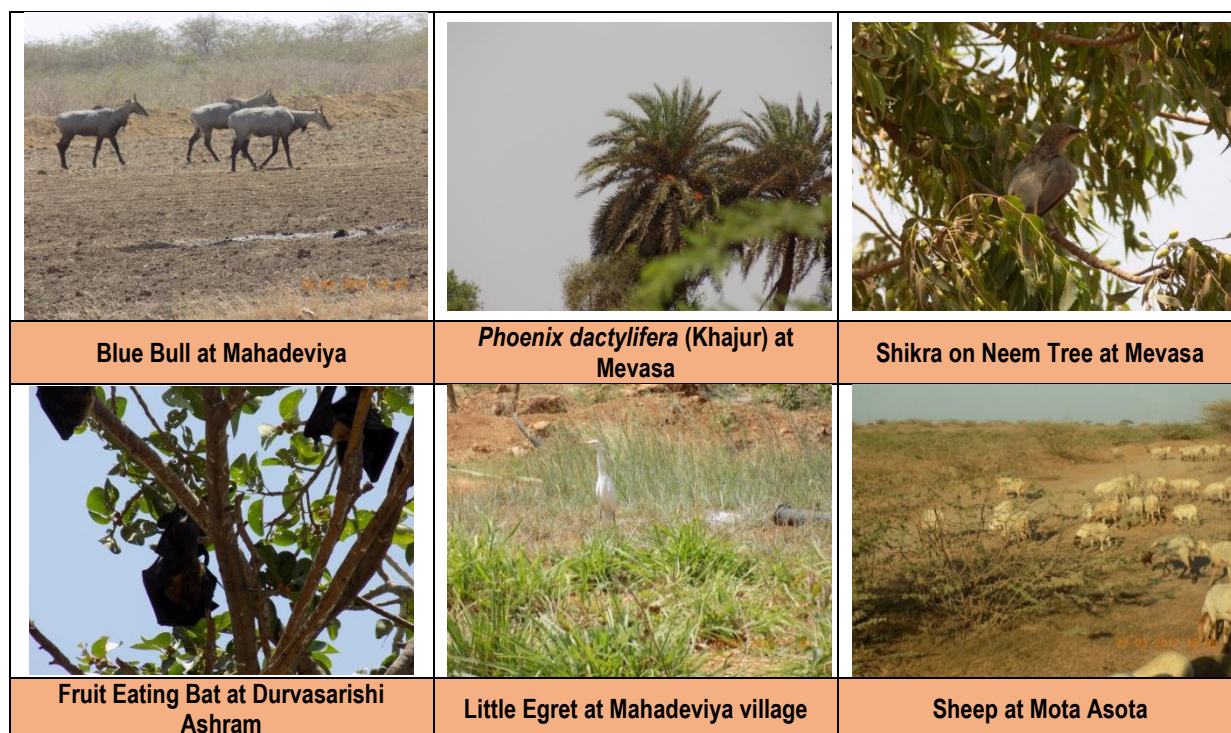


Figure 4. Photos showing different biodiversity

Table 1. List of Trees in the Study area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Fabaceae			
1/1	<i>Acacia nilotica</i>	Desi Baval	+	+
2/2	<i>Butea monosperma</i>	Khakhro	-	+
3/3	<i>Dalbergia sissoo</i>	Sissoo	-	+
4/4	<i>Pongamia pinnata</i>	Karanja	-	+
2.	Rutaceae			
5/1	<i>Aegle marmelos</i>	Bili	-	+
6/2	<i>Limonia acidissima</i>	Kothi	-	+
4.	Cornaceae			+
7/1	<i>Alangium salvifolium</i>	Ankol	-	+
5.	Meliaceae			
8/1	<i>Azadirachta indica</i>	Limdo	+	+
9/2	<i>Soyimida febriguga</i>	Royno	-	+
6.	Combretaceae			
10/1	<i>Terminalia bellerica</i>	Baheda	-	+
11/2	<i>Terminalia arjuna</i>	Arjun	-	+
12/3	<i>Terminalia chebula</i>	Harde	-	+
13/4	<i>Terminalia catappa</i>	Badam	-	+
14/5	<i>Terminalia tomentosa</i>	Sadam	-	+
10.	Arecaceae			
15/1	<i>Phoenix sylvestris</i>	Khajuri	-	+
11.	Myrtaceae			
16/1	<i>Syzygium cumunii</i>	Jambudo		+
12.	Moraceae			
17/1	<i>Ficus carica</i>	Anjir	-	+
18/2	<i>Ficus hispida</i>	Bhoyumro	-	+
19/3	<i>Ficus bengalensis</i>	Vad	+	+
19/4	<i>Ficus racemosa</i>	Umero	-	+
19/5	<i>Ficus religiosa</i>	Pipdo	+	+
12.	Mimosaceae			
20/1	<i>Pithecellobium dulce</i>	Vilayati ambli	-	+

21/2	<i>Albizia odoratissima</i>	Kalo Shirish	-	+
22/3	<i>Albizia lebbbeck</i>	Siras	-	+
23/4	<i>Prosopis cineraia</i>	Khijdo	-	+
13.	Caesalpiniaceae			
24/1	<i>Cassia fistula</i>	Garmalo	-	+
25/2	<i>Tamarindus indica</i>	Amla	-	+
26/3	<i>Bauhinia racemosa</i>	Apto	-	+
14.	Euphorbiaceae			
27/1	<i>Emblia officinalis</i>	Amla	-	+
28/2	<i>Bridelia retusa</i>	Asan	-	+
15.	Rubiaceae			
29/1	<i>Adina cordifolia</i>	Haldarvo	-	+
30/2	<i>Mitragyna parviflora</i>	Kalam	-	+
16.	Sapotaceae			
31/1	<i>Madhuca indica</i>	Mohwa	-	+
32/2	<i>Manilkara hexandra</i>	Khirmi	-	+
17.	Verbenaceae			
33/1	<i>Gmelina arborea</i>	Savan	-	+
34/2	<i>Tectona grandis</i>	Sag	-	+

Table 2. List of Shrub in the Study area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Asclepiadaceae			
1/1	<i>Calotropis procera</i>	Akdo	+	+
2.	Apocynaceae			
2/1	<i>Carissa conchata</i>	Karmada	-	+
3/2	<i>Holarrhena antidysenterica</i>	Kado	-	+
4/3	<i>Catharanthus pusillus</i>	Parvatirai	-	+
3.	Rosaceae			
5/1	<i>Rosa damascena</i>	Rose	-	+
4.	Malvaceae			
5/1	<i>Hibiscus rosa-sinensis</i>	Jasud	-	+
6/2	<i>Hibiscus vitifolius</i>	Van kapas	-	+
7/3	<i>Thespesia lampas</i>	Jungli bhindo	-	+
8/4	<i>Pavonia zeylanica</i>	Ambari	-	+
9/5	<i>Sida acuta</i>	Bala	-	+
10/6	<i>Sida ovata</i>	Dabi	-	+
5.	Solanaceae			
11/1	<i>Datura metel</i>	Dhanturo	-	+
6.	Verbenaceae			
12/1	<i>Lantana camara</i>	Lantana	-	+
7.	Oleaceae			
13/1	<i>Nyctanthes arbor-tristis</i>	Parijata	-	+
8.	Euphorbiaceae			
14/1	<i>Ricinus communis</i>	Divele (Erandi)	-	+
15/2	<i>Acalypha indica</i>	Vinchikanto		
9.	Rhamnaceae			
16/1	<i>Zizyphus mauritiana</i>	Bor	-	+
17/2	<i>Zizyphus galabrata</i>	Bor	-	+
18/3	<i>Zizyphus xylopyra</i>	Ghat Bor	-	+
19/4	<i>Zizyphus rugosa</i>	Toran	-	+
10.	Acanthaceae			
20/1	<i>Peristrophe bicalyculata</i>	Adhedo	-	+
21/2	<i>Adhatoda vasica</i>	Ardusi	-	+
22/3	<i>Dipteracanthus patulus</i>	Dhramandhrokali	-	+
11.	Mimosaceae			
23/1	<i>Prosopis juliflora</i>	Gando Baval	+	+

Table 3. List of Herbs in the Study Area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Papaveraceae			
1/1	<i>Argemone mexicana</i>	Darudi	-	+
2.	Amaranthaceae			
2/1	<i>Aerva sanguinolenta</i>	Gorakhganjo	-	+
3/2	<i>Achyranthes aspera</i>	Anghedi	-	+
3.	Fabaceae			
4/1	<i>Arachis hypogea</i>	Magaphali	-	+
5/2	<i>Cassia tora</i>	Takla	+	+
6/3	<i>Trigonella foenum-graecum</i>	Methi	-	+
4.	Apocynaceae			
7/1	<i>Catharanthus roseus</i>	Sadaphuli	-	+
5.	Solanaceae			
8/1	<i>Capsicum annum</i>	Marchi	-	+
9/2	<i>Datura metel</i>	Ganthovallo Dhanturo	-	+
6.	Apiaceae			
10/1	<i>Centella asiatica</i>	Khadabrahmi	-	+
7.	Malvaceae			
11/1	<i>Hibiscus lobatus</i>	Tali	-	+
8.	Lamiaceae			
13/1	<i>Ocimum sanctum</i>	Tulsi	-	+
9.	Phyllanthaceae			
14/1	<i>Phyllanthus fraternus</i>	Bhuiavali	-	+
10.	Poaceae			
15/1	<i>Andropogon pumilus</i>	Andropogon	-	+
16/2	<i>Arundinella pumila</i>	Bejariyun	-	+
17/3	<i>Pennisetum glaucum</i>	Bajra	-	+
18/4	<i>Setaria halepense</i>	Jangli-jowar	-	+
19/5	<i>Sorghum bicolor</i>	Jowar	-	+
20/6	<i>Triticum aestivum</i>	Wheat	-	+
11.	Liliaceae			
18/1	<i>Chlorophytum tuberosum</i>	Safedmusli	-	+

Table 4. List of Climbers in the Study Area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Vitaceae			
1/1	<i>Cissus repanda</i>	Gandovelo	-	+
2/2	<i>Cissus quadrangulare</i>	Hadsakal	-	+
3/3	<i>Cayratia auriculata</i>	Khat-Khatumbo	-	+
4/4	<i>Cayratia camosa</i>	Khatumbo	-	+
2.	Nyctaginaceae			
5/1	<i>Bougainvillea spectabilis</i>	Booganvel	-	+
3.	Cucurbitaceae			
6/1	<i>Cucurbita maxima</i>	Lal kolu	-	+
7/2	<i>Cucumis sativus</i>	Khira	-	+
8/3	<i>Coccinia grandis</i>	Tondla	-	+
9/4	<i>Momordica dioica</i>	Katwal	-	+
10/5	<i>Cucumis callosus</i>	Tarbucha	-	+
4.	Menispermaceae			
11/1	<i>Cissampelos pareira</i>	Abuta	-	+

Table 5. List of Twinner in the Study Area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Asclepiadaceae			
1/1	<i>Hemidesmus indicus</i>	Sariva	-	+
2/2	<i>Leptadenia reticulata</i>	Meethi dodi	-	+
3/3	<i>Ceropegia bulbosa</i>	Khadula	-	+

2.	Asparagaceae			
4/1	<i>Asparagus racemosus</i>	Shatavari	-	+
3.	Minispermaceae			
5/1	<i>Cocculus hirsutus</i>	Vasanvel	-	+
6/2	<i>Cyclea peltata</i>	Raj Patha	-	+

Table 6. List of Creeper in the Study Area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Convolvulaceae			
1/1	<i>Ipomoea aquatica</i>	Nali	-	+
2/2	<i>Ipomoea eriocarpa</i>	Maal ghanti	-	+
3/3	<i>Ipomoea pes-caprae</i>	Maryada-vel	-	+
2.	Cucurbitaceae			
4/1	<i>Luffa acutangula</i>	Galka	-	+
4/2	<i>Momordica charantia</i>	Karela	-	+

Table 7. List of Parasite in the Study Area

S. No.	Family and Scientific Name	Vernacular Name	Core	Buffer
1.	Convolvulaceae			
1/1	<i>Cuscuta chinensis</i>	Amarvel	-	+
2/2	<i>Cuscuta reflexa</i>	Akashvel	-	+

Table 8. Medicinally Important Plants Observed in the Study Area

S.No.	Scientific Name	Vernacular Name	Core	Buffer
1.	<i>Acacia nilotica</i>	Desi Baval	-	+
2.	<i>Azadirachta indica</i>	Limdo	-	+
3.	<i>Asparagus racemosus</i>	Shatavari	-	+
4.	<i>Adhatoda vasica</i>	Ardusi	-	+
5.	<i>Calotropis procera</i>	Akado	-	+
6.	<i>Cuscuta reflexa</i>	Akashvel	-	+
7.	<i>Datura metel</i>	Dhatura	-	+
8.	<i>Ficus bengalensis</i>	Vad	-	+
9.	<i>Ficus religiosa</i>	Paipal	-	+
10.	<i>Ocimum sanctum</i>	Tulsi	-	+
11.	<i>Catharanthus roseus</i>	Sadaphuli	-	+

Cultivated Plants in the Study Area

The prevalent cropping systems of this area are the cumulative results of past and present decisions by individuals; these decisions are usually based on experience, tradition, expected profit, personal preferences and resources, and so on. The crop occupying the highest percentage of the sown area of this region is taken as the major crop and all other possible alternative crops which are sown in this region either as substitutes of the base crop in the same season or as the crops which fit in the rotation in the subsequent season, are considered as minor crop. No any major/minor and vegetable crop in the core zone was observed during study period, but observed major/minor and vegetable crop in the buffer zone.

a. Major Crops in buffer zone: *Arachis hypogaea* (Groundnut), *Zea mays* (Maize),

Sorghum bicolor (Jowar) and *Pennisetum glaucum* (Bajra).

b. Minor crops in buffer zone: *Triticum aestivum* (Wheat), *Cajanus cajan* (Tur), *Cicer arietinum* (Gram) and *Tagetes* (Marigold crop) for flower.

c. Major horticultural crops in buffer zone: *Mangifera indica* (Kairi), *Manilkara zapota* (Chikku) and *Musa × paradisiaca* (Banana).

d. Major Vegetable crops: The major vegetables grown in the study area (buffer zone) were: *Abelmoschus esculentus* (Bhinda), *Lagenaria siceraria* (Bottle gourd), *Luffa acutangula* (Gilka) and *Momordica charantia* (Bitter gourd).

e. Major Ornamental Plants: Following is the list of ornamental plants in the study area (buffer zone) *Hibiscus rosa-sinensis* (China rose), *Ixora coccinea* (Red ixora), *Rosa* (Rose) and *Tagetes* (Marigold).

Status of the Forest, Their Category in Study Area

As per the S.O. 2561 (22.08.2013) Final ESZ Notification on Marine National Park and Marine Sanctuary, Gujarat. The total area of 326.26 square kilometer around Marine National Park and Marine Sanctuary has been identified as eco-sensitive zone, of which 208.5818 square kilometer is the area towards landward side, 105.14 square kilometer towards sea and 12.5384 square kilometer is the area covered by rivers and the Marine Sanctuary covers an area of 457.92 square kilometer and an area of 162.89 square kilometer as Marine National Park was notified in 1982. The entire southern coast of the Gulf in Jamnagar district is ringed by a cluster of 42 islands and many of them are fringed by coral reefs and mangrove vegetation; And whereas the high density and diversity in the Gulf of Kutch is due to the availability of different types of habitats like sandy, muddy, rocky, calcareous sea bed and coral beds and mangroves in the relatively sheltered waters of the Gulf and is defined as portion of sea partially enclosed by sweep of coast and usually narrower at mouth than bay. The flora of marine National Park mainly consists of mangroves and array of marine algae, including some commercially important species of *Agarophytes* and *Alginophytes* and the coastal line of the Gulf is fringed with luxuriant growth of *Avicennia*, *Rhizophora* and *Ceriops* species of mangroves and *Salvadora*, *Zizipus* and *Prosopis* are some of the terrestrial species found in that area. The Sanctuary has more than 70 sponge species, 37 species of hard coral and 24 species of soft coral, 150-200 species of fishes, 27 species of prawn, 30 species of crab, 200 species of mollusk, 3 species of sea turtle, 3 species of sea snake, 3 species of sea mammal, 94 species of aquatic bird and 78 species of terrestrial bird.

The Central government had notified the area upto a length of one kilometer from the coastal boundary towards landward side, an area within 200 metre from the boundary of Marine National park and Sanctuary towards seaward side and 31 rivers flowing into the Gulf of Kachchh with their length varying from 0 to 5

kilometre and a width of 250 metre from the centre of the river on both sides of river from the boundary of the protected area of Marine National park and Marine Sanctuary in the state of Gujarat as the eco sensitive Zone. Towards landward side area of about 208.58 square kilometer including 36 villages adjoining Marine National Park and Sanctuary and the boundary of the ESZ from coastal boundary towards landward side extends up to a length of one Kilometre which include either whole or part of survey numbers upto this limit of one kilometer. The ESZ toward seaward constitute an area of 105.14 square kilometer and an area within 200 metre from boundary of Marine National Park and Sanctuary towards seaward side has been included in the said Zone. 31 Rivers which flow into the Gulf of Kachchh have been included in the ESZ. The ESZ is bounded by 22°55'31.33" N Latitude and 70°32'57.02" E Longitude towards east; 22°28'1.31" N and 69°3'33.77" E towards west; 22°56'14.26" N and 70°25'54.27" E towards North; 22°13'12.35" N and 69°17'43.97" E towards South. The following activities are to be regulated in the Eco-sensitive Zone, namely:

1. Management Plan for the Marine National Park and Marine Sanctuary Eco-sensitive Zone:

The Management plan shall be prepared by the State Government of Gujarat as per the State Town and Country Planning Act within a period of one year from the date of issue of the final notification. The Management plan shall be prepared in consultation with all concerned State Departments of Environment, Forest, Urban Development, Tourism, Municipal, Revenue and the Gujarat State pollution Control Board with a view to include therein various aspects of the environment and ecology.

- I. The management Plan shall provide for restoration of denuded areas, conservation of existing water bodies, management of catchment areas, watershed management, groundwater management, soil and moisture conservation, needs of local community

- and such other aspects of the ecology and environment the need attention.
- II. The management plan should ensure that no restrictions are imposed on the existing legal land use pattern, as well as the legal infrastructure and activities and same would continue as before. However, the management plan would also factor in improvement of all infrastructure/ activities to be more efficient and eco-friendly.
 - III. The management plan shall demarcate all the existing revenue, revenue expansion areas, forests, green areas, horticultural areas, agricultural areas, orchards, natural springs, natural heritage sites and other environmentally and ecologically sensitive areas. No change of land use from green uses such as orchards, horticultural areas, agriculture, parks and other like places to non-green uses shall be permitted in the Management Plan.
 - IV. There shall be no reduction in Forest Zone, Green Zones and Agricultural Area, Mangrove Area and natural marine and other aquatic ecosystems.
 - V. The Monitoring Committee oversees the proper execution of the Management Plan by all Departments and stakeholders as well. This Committee would also look into the grievances of people and find amicable solution of such grievances.
 - VI. Adequate publicity shall be given to the provisions of the Management Plan.
 - VII. Till the time the Eco-Sensitive Zone is finally notified, management plan prepared, approved by the Ministry and the Monitoring Committee is functional so as to ensure administration of the Eco-Sensitive Zone, all non-forestry developmental activities within the proposed boundary of the eco sensitive zone shall be referred to the Standing

Committee of National Board of Wild Life (NBWL)

2. Activity Prohibited in the Eco-sensitive Zone

Commercial Mining, Setting of Saw Mills, Setting of industries causing pollution, Commercial use of firewood, Establishment of Major hydroelectric projects, Use of production of any hazardous substance, Undertaking activities related to tourism like over-flying the national park area by any aircraft, hot air ballons and activities related to coastal tourism, Discharge of untreated effluent and solid waste in natural water bodies or terrestrial area and Mechanised fishing including fishing by trawlers.

3. Activity Regulated in the Eco-Sensitive Zone

Felling of trees, Establishment of hotels and resorts, Drastic change of agriculture system, Commercial use of natural water resources including ground water harvesting, erection of electrical cables, Fencing of premises of hotels and lodges, Use of Polythene bags by shopkeepers, Widening of roads, Movement of vehicular traffic at night, Introduction of exotic species, Protection of hill slopes and rivers banks and coastal areas, Discharge of treated effluents in natural water bodies or terrestrial area, Air and vehicular pollution, Sign boards and hoardings, Salt work activities Sea water withdrawal and Erection of conveying systems and pipelines.

Mangrove: Mangroves not only simply a type of specialised tree, but also an ecosystem that predominantly consists of mangrove trees. They have a remarkable ability to adapt and survive in their suffocating, saltladen environment. The mangrove (marine and terrestrial) encountered during study period in study area is enlisted in table below.

Table 9. List of Mangrove in the study area

S.No.	Scientific name	Common name	Family
Marine			
1.	<i>Avicennia marina</i>	Grey Mangrove	Acanthaceae
2.	<i>Avicennia officinalis</i>	Indian Mangrove	Acanthaceae
3.	<i>Avicennia alba</i>	-	Acanthaceae
Terrestrial			
4.	<i>Salvadora persica</i>	Toothbrush Tree	Salvadoraceae

5.	<i>Salvadora oleoides</i> Decne	Toothbrush Tree-Big	Salvadoraceae
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Broken shell of Turtle	Live Corals shells	<i>Avicennia marina</i> towards Pindara Jetty

Figure 5. Marine National Park, Jamnagar near Durvasarishi Ashram at sea shore near Pindara village

		
Sign board of Marine National Park	Aerial view of Mangrooves	Live Corals shells
		
Cactus on the way of Mahadev Temple	Eurasian Spoonbill	Dead corals

Figure 6. Marine National Park, Jamnagar near Mahadev Temple at sea shore near Mota Asota

Rare and Endangered Flora in the Study Area: The IUCN Red List is the world's most comprehensive inventory of the global conservation status of plant and animal species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. These criteria are relevant to all species and all regions of the world. With its strong scientific base, the IUCN Red List is recognized as the most authoritative guide to the status of biological diversity. Out of 17000 species of higher plants known to occur in India, nearly 614 higher plant species were evaluated by IUCN. Among them 247 species are under threatened category (IUCN, 2008). Among the enumerated flora in the study area, none of them were assigned any threat category by Red data book of Indian Plants

(Jain and Sastry, 1984; Nayar and Sastry, 1987; 1988; 1990; Oldfield *et al.*, 1998; Kholia and Bhakuni, 2009) and Red list of threatened Vascular plants (IUCN, 2010).

Endemic Plants of the Study Area: De Candolle (1855), Swiss botanist, first used the concept of Endemic, which is defined as an area of a taxonomic unit, especially a species which has a restricted distribution or habitat, isolated from its surrounding region through geographical, ecological or temporal barriers. Out of 17000 species of known flowering plants of India nearly 5000 species are said to be endemic. Nearly 58 genera and 1932 taxa are found to be endemic to peninsular India (Nayar, 1980; Ahmedullah and Nayar, 1986; 1987; Jain 1992; Nayar, 1996; Vijaya Shankar *et al.*, 2005; Nautiyal *et al.*, 2009a,b; Shendage *et al.*,

2010). Among recorded plant species none can be assigned the status of endemic plant of this region in core or buffer zone. None of the rare and endangered floral species were recorded in study area during the field study.

Faunal Biodiversity of Study Area

Birds: The sighting of bird species was very less during the study period. The most commonly spotted bird species of this area were Cattle Egret, Intermediate Egret, Red-wattled Lapwing, Rock Pigeon, Eurasian

Collared-Dove, Chestnut-headed Bee-eater, Bank Myna and Common Myna. Water birds are very common as creek and sea shore line is the major part falls under study area. The Indian Peafowl was observed which is listed as schedule –I as per IWPA, 1972 and others listed as schedule IV as per IWPA, 1972. Systematic account of the birds in the study area with the status of occurrence is given in the Table below.

Table 10. Systematic Lists of Birds encountered in the Study Area

S.No	Scientific Name	Local Name	Common Name	Schedule/IUCN	Status
1.	<i>Accipiter badius</i>	Shakro	Shikra	Schedule IV	R
2.	<i>Acridotheres ginginianus</i>	Ghoda kabar	Bank Myna	Schedule IV	R
3.	<i>Alauda gulgula</i>	Jad Agan	Oriental Sky Lark	Schedule IV	M
4.	<i>Amaurornis phoenicurus</i>	Safed chatari	White-breasted Water hen	Schedule IV	R
5.	<i>Aquila heliaca</i>	Shahi Garud	Imperial Eagle	Vulnerable	R
6.	<i>Ardeola grayii</i>	Khokhadbaglo	Indian pond heron	Schedule IV	R
7.	<i>Bubulcus ibis</i>	Dhorbaglo	Cattle Egret	Schedule IV	RM
8.	<i>Centropus sinensis</i>	Hoco	Crow-Pheasant	LC	R
9.	<i>Columba livia</i>	Kabutar	Blue Rock Pigeon	LC	R
10.	<i>Coracias benghalensis</i>	Deshi Neelkanth	Indian Roller	LC	R
11.	<i>Covus splendens</i>	Kagdo	Crow	Schedule IV	R
12.	<i>Dicrurus macrocercus</i>	Kado kosi	Black drongo	LC	R
13.	<i>Egretta garzetta</i>	Baglo	Little Egret	Schedule IV	R
14.	<i>Elanus caeruleus</i>	Kapasi/Laudharo	Black-winged Kite	Schedule IV	R
15.	<i>Fulica atra</i>	Dasadi	Coot	Schedule IV	R
16.	<i>Grus grus</i>	Kunj	Common Crane	Schedule IV	R
17.	<i>Halcyon smyrnensis</i>	Moto Kalkalio	White-throated Kingfisher	Schedule IV	R
18.	<i>Lanius excubitor</i>	Dhori lefaddi	Great Grey Shrike	Schedule IV	RM
19.	<i>Merops leschenaulti</i>	Tarklo	Chestnut-headed Bee-eater	LC	R
20.	<i>Motacilla flava</i>	Pilo Divaliyo	Yellow Wagtail	Schedule IV	RM
21.	<i>Muscicapa striata</i>	Nanu Chikyu	Spotted Flycatcher	Schedule IV	R
22.	<i>Mycteria leucocephala</i>	Dhonk	Painted Stork	Schedule IV	RM
23.	<i>Nectarinia asiatica</i>	Jāmbālī Sunbird	Purple Sunbird	Schedule IV	R
24.	<i>Passer domesticus</i>	Chakli	House sparrow	LC	R
25.	<i>Pavo cristatus</i>	Mor	Indian Peafowl	Schedule I	R
26.	<i>Phalacrocorax fuscicollis</i>	Vichetkajio	Cormorant	Schedule IV	R
27.	<i>Phalacrocorax niger</i>	Nanokajio	Little Cormorant	Schedule IV	RM
28.	<i>Philomachus pugnax</i>	Tilio	Ruff	LC	R
29.	<i>Phoenicopiterus minor</i>	Nano Surkabh	Lesser Flamingo	Schedule IV	RM
30.	<i>Platalea leucorodia</i>	Chamchichanch	Eurasian Spoonbill	Schedule IV	P
31.	<i>Ploceus philippinus</i>	Sugari	Baya weaver	Schedule IV	R
32.	<i>Psittacula krameri</i>	Popat	Rose-ringed Parakeet	Schedule IV	R
33.	<i>Pseudibis papillosa</i>	Kaadi	Red-naped ibis	Schedule IV	R
34.	<i>Sternula albifrons</i>	Nana vabagli	Little Tern	LC	R
35.	<i>Streptopelia decaocto</i>	Holdi	Eurasian Collared-Dove	Schedule IV	R
36.	<i>Streptopelia orientaii</i>	Holdi	Rufous Turtle Dove	Schedule IV	RM
37.	<i>Tachybaptus ruficollis</i>	Dubki	Little Grebe	Schedule IV	R
38.	<i>Throskiornis melanocephalus</i>	Dhorikankansar	Black headed ibis	Schedule IV	M

39.	<i>Turdoides caudatus</i>	Lelu	Common Babbler	Schedule IV	R
40.	<i>Vanellus indicus</i>	Titodi	Lapwing	Schedule IV	R

Note: R-Resident, M- Migratory, RM – Resident & Migratory

Table 11. List of Birds in the Gulf

S. No.	Common name	Scientific name	Status habitat
1.	Podicipedidae		
1/1	Great Crested Grebe	<i>Podiceps cristatus</i>	LM
2/2	Blacknecked Grebe	<i>Podiceps nigricollis</i>	M
2.	Pelecanidae		
3/1	White Pelican	<i>Pelecanus onocrotalus</i>	LM
4/2	Dalmatian Pelican	<i>Pelecanus crispus</i>	M
3.	Phalacrocoracidae		
5/1	Cormorant	<i>Phalacrocorax carbo</i>	LM
6/2	Indian Shag	<i>Phalacrocorax fuscicollis</i>	LM
7/3	Little Cormorant	<i>Phalacrocorax niger</i>	LM
8/4	Darter	<i>Anhinga rufa</i>	LM
4.	Ardeidae		
9/1	Grey Heron	<i>Ardea cinerea</i>	LM
10/2	Purple Heron	<i>Ardea purpurea</i>	LM
11/3	Little Green Heron	<i>Ardeola striatus</i>	LM
12/4	Pond Heron	<i>Ardeola grayii</i>	LM
13/5	Cattle Egret	<i>Bubulcus ibis</i>	-
14/6	Large Egret	<i>Ardea alba</i>	LM
15/7	Smaller Egret	<i>Egretta intermedia</i>	LM
16/8	Little Egret	<i>Egretta garzetta</i>	LM
17/9	Indian Reef Heron	<i>Egretta gularis</i>	LM
18/10	Night Heron	<i>Nycticorax nycticorax</i>	LM
5.	Ciconiidae		
19/1	Painted Stork	<i>Mycteria leucocephala</i>	LM
20/2	Blacknecked Stork	<i>Ephippiorhynchus asiaticus</i>	LM
6.	Threskiornithidae		
21/1	White Ibis	<i>Threskiornis aethiopica</i>	LM
22/2	Black Ibis	<i>Pseudibis papillasa</i>	-
23/3	Spoonbill	<i>Platalea leucorodia</i>	LM
7.	Phoenicopteridae		
24/1	Flamingo	<i>Phoenicopiterus roseus</i>	LM
25/2	Lesser Flamingo	<i>Phoenicopiterus minor</i>	LM
8.	Anatidae		
26/1	Ruddy Shel duck	<i>Tadorna ferruginea</i>	-
27/2	Pintail	<i>Anas acuta</i>	M
28/3	Common Teal	<i>Anas crecca</i>	M
29/4	Spotbill Duck	<i>Anas poecilorhyncha</i>	LM
30/5	Shoveller	<i>Anas clypeata</i>	M
9.	Accipitridae		
31/1	Brahminy Kite	<i>Haliastur indus</i>	LM
32/2	Marsh Harrier	<i>Circus aeruginosus</i>	M
33/3	Osprey	<i>Pandion haliaetus</i>	M
10.	Gruidae		
34/1	Common Crane	<i>Grus grus</i>	M
35/2	Demoiselle Crane	<i>Anthropoides virgo</i>	M
11.	Rallidae		
36/1	Coot	<i>Fulica atra</i>	LM
12.	Jacaniidae		
37/1	Pheasant - tailed Jacana	<i>Hydrophasianus chirurgus</i>	LM
13.	Haematopodidae		
38/1	Oystercatcher	<i>Haematopus stralegus</i>	M
14.	Charadriidae		

39/1	Redwattled Lapwing	<i>Vanellus indicus</i>	R
40/2	Grey Plover	<i>Pluvialis sugotarola</i>	M
41/3	Eastern Golden Plover	<i>Pluvialis dominica</i>	-
42/4	Large Sand Plover	<i>Charadrius leschenaultii</i>	M
43/5	Ringed Plover	<i>Charadrius hiaticula</i>	R
44/6	Kentish plover	<i>Charadrius alexandrinus</i>	R
45/7	Lesser Sand Plover	<i>Charadrius mongolus</i>	M
46/8	Whimbrel	<i>Numenius phaeopus</i>	M
47/9	Curlew	<i>Numenius arquata</i>	M
48/10	Blacktailed Godwit	<i>Limosa limosa</i>	M
49/11	Bartailed Godwit	<i>Limosa lapponica</i>	M
50/12	Spotted Redshank	<i>Tringa erythropus</i>	M
51/13	Common Redshank	<i>Tringa totanus</i>	M
52/14	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M
53/15	Greenshank	<i>Tringa nebularia</i>	M
54/16	Green Sandpiper	<i>Tringa ochropus</i>	M
55/17	Wood Sandpiper	<i>Tringa glareola</i>	M
56/18	Terek Sandpiper	<i>Tringa terek</i>	M
57/19	Common Sandpiper	<i>Tringa hypoleucos</i>	M
58/20	Turnstone	<i>Arenaria interpres</i>	M
59/21	Knot	<i>Calidris carutus</i>	-
60/22	Eastern Knot	<i>Calidris tenuirostris</i>	-
61/23	Sanderling	<i>Calidris alba</i>	-
62/24	Eastern Little Stint	<i>Calidris ruficollis</i>	-
63/25	Little Stint	<i>Calidris minuta</i>	M
64/26	Dunlin	<i>Calidris alpina</i>	M
65/27	Curlew-Sandpiper	<i>Calidris testacea</i>	M
66/28	Broadbilled Sandpiper	<i>Limicola falcinellus</i>	M
67/29	Ruff and Reeve	<i>Philomachus pugnax</i>	M
68/30	Rednecked Phalarope	<i>Phalaropus lobatus</i>	M
15.	Recurvirostidae		
69/1	Blackwinged Stilt	<i>Himantopus himantopus</i>	R
70/2	Avocet	<i>Recurvirostra avosetta</i>	LM
16.	Dromadidae		
71/1	Crab Plover	<i>Dromas ardeola</i>	M
17.	Burhinidae		
72/1	Great Stone Plover	<i>Esacus magnirostris</i>	LM
18.	Laridae		
73/1	Herring Gull	<i>Larus argentatus</i>	M
19.	Lesser Blackbacked		
74/1	Gull	<i>Larus fuscus</i>	M
75/2	Blackheaded	<i>Larus ichthyaetus</i>	M
76/3	Brownheaded Gull	<i>Larus brunnicephalus</i>	M
77/4	Blackheaded Gull	<i>Larus ridibunds</i>	M
78/5	Slenderbilled Gull	<i>Larus genei</i>	M
79/6	Whiskered Tern	<i>Chiildonias hybrida</i>	M
80/7	Whitewing Black	<i>Chiildonias leucopterus</i>	M
20.	Tern		
81/1	Gullbilled Tern	<i>Gelochelidon nilotica</i>	M
82/2	Caspian Tern	<i>Hdroprogne caspia</i>	LM
83/3	Common Tern	<i>Sterna hirunda</i>	M
84/4	Whitecheeked Tern	<i>Sterna repressa</i>	M
85/5	Brownwinged Tern	<i>Sterna anaethetus</i>	M
86/6	Little Tern	<i>Sterna albitrons</i>	M
87/7	Saunders Little Tern	<i>Sterna saundersi</i>	LM
88/8	Large Crested Tern	<i>Sterna bergii</i>	M
89/9	Indian Lesser Crested Tern	<i>Sterna bengalenis</i>	M
90/10	Indian skimmer	<i>Rynchops albigollis</i>	LM

91/11	Sandwich Tern	<i>Sterna sandvicensis</i>	M
21.	Alcedinidae		
92/1	Common Kingfisher	<i>Alcedo atthis</i>	LM
93/2	Whitebreast	<i>Halcyon smymensisq</i>	LM
94/3	Blackcapped kingfisher	<i>Halcyon pileata</i>	M

R: Resident has been recorded breeding during the study.

LM: Local migrant, has not been recorded breeding during the study, but is known to nest within the state.

M: Migrant, does not breed in this area, spends the winter here and also sometimes the summer.

V: Not normally found in the area, one too few records only.

Migratory Pattern: Migration is the best studied of animal behaviours, yet few empirical studies have tested hypotheses explaining the ultimate causes of these cyclical annual movements. Fretwell's (1980) hypothesis predicts that if nest predation explains why many tropical birds migrate uphill to breed, then predation risk must be negatively associated with elevation. The proportion of nests depredated by different types of predators differed among elevations. In present study,

total 90 bird species were recorded belongs to 21 family and almost are widespread resident species while Grey Heron was resident and winter visitor.

Herpetofauna: In amphibian group, the toads were sighted during the study period. The reptile, Common Garden Lizard, House Gecko and Fan-Throated Lizard, Common rat Snake and were observed in the region is given in the Table below.

Table 12. List of Reptiles in the Study Area

S. No.	Scientific Name	Common Name	Schedule as per WPA 1972
1.	<i>Calotes versicolor</i>	Common garden lizard	Not listed
2.	<i>Calotes rouxi</i>	Roux's fores lizard	Not listed
3.	<i>Sitana ponticeriana</i>	Fan-throated lizard	Not listed
4.	<i>Chameleon zeylanicus</i>	Indian chameleon	Not listed
5.	<i>Naja naja</i>	Indian cobra	Schedule II
6.	<i>Hemidactylus flaviviridis</i>	House Gecko	Not listed
7.	<i>Daboia russelli</i>	Russell's viper	Schedule II
8.	<i>Bungarus caeruleus</i>	Common Indian Krait	Schedule IV
9.	<i>Xenochrophis piscator</i>	Checkered keelback	Schedule II
10.	<i>Echis carinatus</i>	Indian saw scaled viper	-

Table 13. Mammals in Study Area

S.No.	Common Name	Scientific name	Status as per IWPA 1972/IUCN
1.	Five striped Palm Squirrel	<i>Funambulus pennantii</i>	Schedule IV
2.	Indian flying fox/Fruit bat	<i>Pteropus giganteus</i>	LC
3.	Indian Hare	<i>Lepus nigricollis</i>	Schedule IV
4.	Blue Bull	<i>Boselaphus tragocamelus</i>	Schedule III
5.	Small Asian mongoose	<i>Herpestes javanicus</i>	Schedule II

Table 14. List of Marine Fish

S.No.	Common name	Scientific name
1.	Pomfret	<i>Pampus Chinensis</i>
2.	Indian Prawn	<i>Penaeus indicus</i>
3.	Blue Spot Grey Mullet	<i>Valamugil seheli</i>
4.	Grey Mullet	<i>Mugil cephalus</i>
5.	Mullet	<i>Mugil dussumieri</i>
6.	Indian Salmon	<i>Eleutheronema tetradactylum</i>
7.	Bombay Duck (Bumla)	<i>Horpodon neherius</i>
8.	Thread Fin	<i>Polynemus indicus</i>
9.	Mud Skipper	<i>Boleophthalmus</i>
10.	Hilsa shad	<i>Tenuulosa ilisha</i>
11.	Jew fish	<i>Pseudoscioena sp.</i>
12.		<i>Pristopomas sp.*</i>

13.	<i>Diacanthus sp.*</i>
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*not seen directly

Domestic Animals: Camel, Bull, Buffalo, Sheep, Cow, Goat, etc.

Insects like Wasps, Honeybees and Signature spider was also recorded.

Rare and Endangered Fauna of Study Area:

The IUCN Red List is the world's most comprehensive inventory of the global conservation status of plant and animal species. It uses a set of criteria to evaluate the extinction risk of thousands of species and subspecies. Among the birds in the study area, Pea fowl (*Pavo cristatus*) is included in schedule I of Wild life protection Act (1972), while many other birds are included in schedule IV. Among the reptiles, Indian Cobra (*Naja naja*), *Daboia russelli* (Russell's viper) and *Xenochrophis piscator* (Checkered keelback) is provided protection as per Schedule-II of Wild life Protection Act, (1972).

Endemic Fauna of the Study Area: None of the sighted animal species can be assigned endemic species category of the study area.

Marine Ecology

The Gulf that opens to the north-eastern Arabian Sea has channel depths varying from 20 m at the head to 60 m in central areas of the outer Gulf. Within the Gulf, though water depths of 25 m exist in the broad central portion upto a longitude 70° E, the actual fairway is obstructed by the presence of several shoals. The high tidal influx covers the low lying areas of about 1500 km² comprising networks of creeks and alluvial marshy tidal flats in the interior region. The creek system consists of three main creeks namely Nakti, Kandla and Hansthal and little Gulf of Kachchh interconnecting through many other big and small creeks. All along the coast, very few rivers drain into the Gulf and they carry only a small quantity of freshwater, except during brief monsoon. The southern shore of the Gulf has numerous islands and inlets covered with mangroves and surrounded by coral reefs. The northern shore is predominantly sandy or muddy confronted by numerous shoals.

Physical Processes: Tides in the Gulf are of mixed, predominantly semidiurnal type with a large diurnal inequality. The complex

bathymetry, rugged bottom topography and undulations in the shoreline produce highly non-linear tidal interactions. The tidal front enters the Gulf from the west and due to shallow inner regions and narrowing cross-section, the tidal amplitude increases considerably, upst ream of Vadinar. The tidal elevations (m) along the southern Gulf are as follows:

Location	MHWS	MHWN	MLWN	MLWS	MSL
Okha	3.47	2.96	1.20	0.41	2.0
Sikka	5.38	4.35	1.74	0.71	3.0
Rozi	5.87	5.40	1.89	1.0	3.6
Kandla	6.66	5.17	1.81	0.78	3.9
Navlakhi	7.21	6.16	2.14	0.78	4.2

Thus, over the length of the Gulf the mean spring tidal range increases impressively from 3.47m at Okha to 7.21m at Navlakhi. The phase lag between Okha and Kandla is 2 h to 2 h 25 min while between Okha and Navlakhi it is 3 h to 3 h 20 min. Due to high tidal ranges in the inner regions, the vast mudflats and coastal low lands which get submerged during high tide are fully exposed during low tide. Circulation in the Gulf is mainly controlled by the tidal flows and bathymetry though wind effect also prevails to some extent. The maximum surface currents are moderate (0.7-1.2 m/s) but increase considerably (2.0 - 2.5 m/s) in the central portion of the Gulf. The spring currents are 60 to 65 % stronger than the neap currents. The bottom currents are also periodic with a velocity normally 70 % of the surface currents. Modelling of tides and currents in the Gulf indicate that (a) in the eastern half of the Gulf, the circulation favours an eastward transport towards Kandla (along the northern rim of the Gulf) with a tendency to form a clockwise circulation, (b) in the western Gulf, the residual circulation presents anti-clockwise eddies of different sizes, except one clockwise eddy in the northern Gulf (off Mandvi), (c) the net transport from the open ocean into the Gulf is through the southern side of the mouth and the net outward transport is through the northern side, forming an anti-clockwise circulation in the western part, and (d) as the Gulf width

suddenly drops at the mid-Gulf and coastal orientation changes abruptly thereafter, the water flow is deflected towards north and forms a dynamic barrier across Sikka-Mundra section that retards the flushing of the Gulf.

Water Quality: The general water quality of the Gulf in pre and post-monsoon seasons is compiled for different years. The annual variation of water temperature is between 20°C and 30°C though localised higher temperatures upto 35°C can result in isolated water pools formed in shallow intertidal depressions, during low tide. Vertical profiles of temperature and salinity reveal a nearly homogeneous water column with no vertical stratification due to intense tidal-driven turbulence mixing. Suspended Solids are highly variable, spatially as well as temporally, and largely resulted from the dispersion of fine sediment from the bed and the intertidal mudflats, by tidal movements. Evidently, near shore shallow regions invariably sustain higher SS as compared to the central zones. The region between Okha and Sikka has high variable SS (4-308 mg/L) whereas the inner Gulf areas sustain markedly higher SS, even up to 700 mg/L. The pH range of the Gulf water is remarkably constant (8.0-8.3) though wide variations (7.6-8.8) are not iced sometimes.

The evaporation exceeds precipitation leading to salinities markedly higher than that of the typical seawater. This is particularly evident in the inner Gulf where salinities as high as 40 psu commonly occur off Kandla and Navlakhi. Although the salinities decrease considerably for a brief period in some creeks of the Little Gulf of Kachchh under the influence of monsoonal runoff, the 20 impact of this decrease in the Gulf proper is small and salinities often exceed 36 psu at most of the locations. The average DO is fairly high (35 mg/L) most of the times and the BOD is low (<0.1 - 6.3 mg/L) indicating good oxidising conditions. The nutrients (PO₄³⁻-P, NO₃⁻-N, NO₂⁻-N, NH₄⁺-N) are more or less uniformly distributed in the Okha-Sikka-Mundra segment and their concentrations indicate healthy natural waters. Their levels however are marginally high in the Kandla-Navlakhi

segment. Infact, the network of creeks of the Little Gulf of Kachchh sustains high natural concentrations of nutrients perhaps due to high regeneration rates. As expected for a unpolluted coastal environment, the concentrations of PHC and phenols are low.

Sediment Quality: Central portion of the Gulf extending from the mouth to upstream of Sikka is rocky with sediments confined only to the margins. The nearshore sediment which consists of light gray silt and clay and fine sand with patches of coarse sand in-between, are poorly sorted with highly variable skewness. The major source of this sediment is considered to be the shore material and the load transported by the Indus River. The portion of sediment derived from the hinterland is considered to be small because of the low run-off. Moreover, the streams discharging in the Gulf (during brief monsoon season) are short with dams constructed on many of them. The concentrations of heavy metals such as chromium, manganese, cobalt, nickel, copper, zinc, mercury and lead though variable, indicate natural background levels and there is no evidence of gross sediment contamination. The concentrations of PHC are also low though large quantities of petroleum crude and its products are handled at Vadinar, Sikka, Mundra and Kandla.

Marine Biodiversity

The Gulf abounds in marine wealth and is considered as one of the biologically richest marine habitat along the west coast of India. The marine flora is highly varied and includes sand dune vegetation, mangroves, seagrasses, macrophytes and phytoplankton. In all 31 species of Chlorophyceae, 33 species of Phaeophyceae and 55 species of Rhodophyceae have been identified with the dominance of Phaeophyceae. The dominant species of sand dune flora are *Euphorbia caducifolia*, *E. neriifolia*, *Aloevera* sp, *Ephedra foliata*, *Urochorda setulosa*, *Sporobolus maderaspatenus*, *Eragrostis unioides*, *Calotropis procera*, *Fimbristylis* sp, *Indigofera* sp and *Ipomoea pescaprae*. The common seagrasses found growing on the mud flats are *Halophila ovata*, *H. beccarii* and *Zostrea marina*. The most common marine algal

species are *Ulva fasciata*, *U. reticulata*, *Enteromorpha intestinalis*, *Dictyota* sp, *Hypnea musciformis*, *Sargassum tennerimum*, *S. ilicifolium*, *Gracilaria corticata*, *Cystocera* sp, *Padina tetrastomatica*, *Corallina* sp, *Laurencia* sp, *Caulerpa racemosa*, *Bryopsis* sp, *Turbinaria* sp, *Ectocarpus* sp, *Acanthophora* sp, *Chondria* sp, and *Codium* sp.

The primary production of the water column as assessed from chlorophyll a concentration is generally high in the outer Gulf but decreases in the inner regions. Phytoplankton represents about 31 genera and 41 species. The major phytoplankton genera are *Rhizosolenia*, *Synedra*, *Chaetoceros*, *Navicula*, *Nitzschia*, *Pleurosigma*, *Thalassiothrix*, *Biddulphia*, *Stauroneis*, *Coscinodiscus* and *Skeletonema*. The Gulf also sustains good and variable zooplankton and benthic standing stock with diversity. The primary and secondary trophic levels offer congenial feeding grounds for prawns and fishes in the Gulf. The vast intertidal zone of the Gulf is rich in biota. Sheltered bays, creeks and mud flats provide ideal sites for mangrove vegetation over an estimated area of about 1066.9 km². The formations are of open scrubby type, with isolated and discontinuous distribution from Kandla-Navlakhi in the northeast to Jodia, Jamnagar, Sikka, Salaya and Okha in the southwest, as also at Pirotan, Positra, Dohlan and Dwarka. Vast stretches of mangroves also exist along the northern shore of the Gulf. The dominant species of mangroves are *Avicennia marina* var *acutissima*, *A. officinalis*, *Bruguiera parviflora*, *B. gymnorhiza*, *Rhizophora mucronata*, *R. apiculata*, *Ageiceros corniculata*, *Ceriops tagal* and *Sonneratia apetata* along with the associated species of *Salicornia brachiata*, *Rosella Montana*, *Suaeda fruticosa*, *Artiplex stocksii* and *lichen*.

The marine fauna of the Gulf is rich, both in variety and abundance. Sponges having an array of colours are observed, both in the intertidal and subtidal biotopes. The common species of sponge is *Adocia* sp, associated with coral reef fauna. In sandy and silty mud shores, *Tetilla dactyloidea* (Carter) is common.

The most frequently encountered hydrozoans are *Sertularia* sp and *Plumularia* sp. The giant sea-anemone (*Stoichactis giganteum*) is a common sight in the coral ecosystem. Sea anemones, belonging to *Anemonia*, *Bunodactis*, *Paracondylactis*, *Anthopleura* and *Metapeachia*, are wide spread. Azoantharian, *Gemmaria* sp, is found forming extensive hexagonal green mats in the coral pools. Another interesting actinarian is the *Cerianthus* sp found in tubes in the soft mud. One of the most interesting biotic features of the Gulf is the presence of living corals, thriving as patches, rather than reefs, either on the intertidal sand stones or on the surface of wave-cut, eroded shallow banks along the southern shore of the Gulf. The Gulf has 42 islands, 34 of which have live corals. Siltation is the main cause affecting the coral growth. The species diversity however is poor with identification of 36 species of Scleractinian and 12 species of soft corals.

A number of polychaete worms, both sedentaria and errantia, with the dominant genera of *Eurythoe*, *Terebella*, *Polynoe*, *Iphione* and *Nereis* are rather common. Amongst a variety of sipunculid and echiuroid worms, the dominant species are *Dendrostromum* sp, *Asphidosiphon* sp and *Ikadella misakiensis* (*Ikeda*). The intertidal crustacean fauna is very rich and equally diverse with spider crab (*Hyas* sp) and furry crab (*Pilumnus* sp), as specialities. Amongst the invertebrate component of the marine fauna of the Gulf, the molluscs have the highest representatives. As many as 92 species of bivalves, 55 species of gastropods, 3 species of cephalopods and 2 species each of scaphopods and amphineurans have been reported. The most notable members of the molluscan fauna are octopus, pearl oyster and a variety of chanks, including the sacred chank. *Pinna bicolor*, the bivalve is commonly noticed in the coral reef flat. The echinoderm fauna, represented by 4 classes and 14 genera, have the commonest genera of *Palmspis*, *Astropecten*, *Asteria*, *Temnopleura* and *Holothuria*. The subtidal benthic fauna of the Gulf is dominated by polychaetes, crustaceans, echinoderms, gastropods and bivalves, with an

average biomass of 25 g/m². The Gulf has a variety of exploitable species of finfishes and shellfishes. The sciaenids, polynemids, perches, eels, cat-fishes, elasmobranchs and prawns are commercially important groups with an average catch of 1.4 x 10⁵ t/y. fishing grounds for Ghol, Karkara, Khaga, Dhoma, Magra and Musi exist in the Gulf. The Gulf region offers plenty of facilities for feeding, breeding and shelter to a variety of birds. In the mangrove forests lining the islands and along the coast, the birds find a near perfect environment. In addition, they are well placed to reach their food supply i.e. the shoals of fish, squids, mud skippers and other animals, during low tide. All along the creeks and around islands, mangrove trees and mudflats are seen crowded with Grey Herons, Pond Herons, Painted Storks, Large and small Egrets, Darters, Cormorants, Flamingos, Lesser Flamingos, etc during the periods of seasonal migration (November-March).

The large congregations of uncommon coastal waders such as Bar-tailed Godwit (*Limosa lapponica*), Sanderling (*Calidris alba*), Large Sand Plover (*Charadrius leschenaultii*), Eurasian Curlew (*Numenius arquata*), Eurasian Oystercatcher (*Haematopus ostralegus*) and Crab Plover (*Dromas ardeola*) occur only in the Gulf. As per the Bird Life International Red Data List and IUCN 2002 Red Data Book, the MNP is home to several globally threatened species, such as Spot-billed Pelican (*Pelecanus philippensis*), Dalmatian Pelican (*P. crispus*), Greater Spotted Eagle (*Aquila*

clanga), Indian Skimmer (*Rhynchops albicollis*), Black-necked Stork (*Ephippiorhynchus asiaticus*) and Pallas's Fishing Eagle (*Paliaeetus leucoryphus*). The Gulf region is also important for marine turtles and sea mammals. Though a detailed systematic survey of biota is lacking, following number of species have been reported:

Flora/Fauna	Species (Nos)
Algae	130
Molluscs	200
Sponges	70
Crabs	30
Corals	56
Birds	200
Fishes	200
Sea mammals	3
Sharks	8
Sea turtles	3
Prawns	27

Because of its high biogeographical importance and rich flora and fauna, several areas along the southern Gulf are notified under the Marine National Park (16,289 ha) and the Marine Sanctuary (29,503 ha).

Planktonic and Benthic Habitat

Survey was conducted for the study of planktonic and benthic habitat. Study of biological status of any waterbody play an important role in assessing the causes of impact on water body and quality of the water. Here the biological parameter considered during EB survey are primary productivity, phytoplankton count, pigment Analysis, Zooplankton count, availability of benthic organism, fish and other micro habitat.

Table 15. List of intertidal Algae of the Gulf

Name	Status*	Name	Status*	Name	Status*
Chlorophyceae		Phaeophyceae		Rhodophyceae	
<i>Boodlea composita</i>	C	<i>Colpomenia sinuosa</i>	C	<i>Acanthophora delilei</i>	C
<i>Bryopsis indica</i>	C	<i>Cystoceira indica</i>	C	<i>A. specifera</i>	R
<i>B. plumose</i>	C	<i>Dictyota atomaria</i>	C	<i>Amphiroa fragillissima</i>	R
<i>B. ramulosa</i>	C	<i>D. bartayrisiana</i>	R	<i>Asparagopsis taxiformis</i>	C
<i>Caulerpa crassifolia</i>	C	<i>D. cervicornis</i>	R	<i>Botryocladia leptapoda</i>	C
<i>C. cupressoides</i>	C	<i>D. ciliolate</i>	C	<i>Calaglossa bombayance</i>	R
<i>C. racemosa</i>	C	<i>D. dichotoma</i>	C	<i>Ceramium sp.</i>	C
<i>C. scalpelliformis</i>	C	<i>D. divaricata</i>	R	<i>Champia indica</i>	C
<i>C. sertularioides</i>	C	<i>Dictyopteris australis</i>	C	<i>Chondria ornata</i>	R
<i>C. taxiformes</i>	C	<i>D. woodwardii</i>	C	<i>C. dasyphylla</i>	R
<i>C. verticillata</i>	C	<i>Ectocarpus sp.</i>	C	<i>Coelarthrum opuntia</i>	C
<i>Chaetomorpha indica</i>	C	<i>Hinskia mitchelle</i>	C	<i>Corallina officinalis</i>	C
<i>Chamaedoris auiculata</i>	C	<i>Hormophysa triquetra</i>	R	<i>Corynomorpha</i>	R

				<i>prismatica</i>	
<i>Cladophora glomerata</i>	C	<i>Hydroclathrus clathratus</i>	R	<i>Cryptopleur sp.</i>	R
<i>C. prolifera</i>	C	<i>Iyengaria stellata</i>	C	<i>Dasya sp.</i>	R
<i>Codium decorticatum</i>	R	<i>Myriogloea sciurus</i>	R	<i>Desmia hornmanni</i>	R
<i>C. dwarkensis</i>	C	<i>Nemacystus decipiens</i>	R	<i>Gastroclonium iyengarii</i>	R
<i>C. elongatum</i>	C	<i>Padina gymnospora</i>	R	<i>Galaxaura oblongata</i>	C
<i>Dictyosphaeria cavernosa</i>	C	<i>P. tetrastromatica</i>	C	<i>Gelidiella acerosa</i>	C
<i>Enteromorpha intestinalis</i>	C	<i>Pocockiella sp.</i>	C	<i>Gelidiospsis gracilis</i>	C
<i>Halideda tuna</i>	C	<i>Rosenvingia intricata</i>	R	<i>Gigartina sp</i>	R
<i>Pseudobryopsis mucronata</i>	R	<i>Sargassum johnstonii</i>	C	<i>Gracilaria corticata</i>	R
<i>Spongomorpha sp.</i>	C	<i>S. tenerimum</i>	C	<i>G. pygmaea</i>	C
<i>Udoea indica</i>	C	<i>S. plagiophyllum</i>	R	<i>Gastroclonium iyengarii</i>	R
<i>Ulva fasciata</i>	C	<i>S. swartzii</i>	C	<i>Galaxaura oblongata</i>	C
<i>U. lactuca</i>	C	<i>S. wisgthii</i>	R	<i>Gelidiella acerosa</i>	C
<i>U. reticulata</i>	R	<i>Spathoglossum asperum</i>	R	<i>Valonia utricularis</i>	R
<i>Valonia utricularis</i>	R	<i>S. variable</i>	C	<i>Valloniopsis spachynema</i>	R
<i>Valloniopsis spachynema</i>	R	<i>Gelidiospsis gracilis</i>	C	-	-
<i>Stoechospermum marginatum</i>	C	<i>Gigartina sp</i>	R	-	-
<i>Spathoglossum asperum</i>	R	<i>Gracilaria corticata</i>	R	-	-
<i>S. variable</i>	C	<i>G. pygmaea</i>	C	-	-
<i>Stoechospermum marginatum</i>	C	<i>G. verrucosa</i>	R	-	-
<i>Turbinaria ornata</i>	R	<i>Grateloupia inica</i>	C	-	-
-	-	<i>G. felicina</i>	R	-	-
-	-	<i>Haloplegma sp.</i>	R	-	-
-	-	<i>Halymenia floresia</i>	R	-	-
-	-	<i>H. porphyroides</i>	C	-	-
-	-	<i>H. venusta</i>	C	-	-
-	-	<i>Helminthocladia clayadosii</i>	C	-	-
-	-	<i>Heterosiphonia muelleri</i>	C	-	-
-	-	<i>Hypnea cervicornis</i>	C	-	-
-	-	<i>H. musciformis</i>	C	-	-
-	-	<i>Hypoglossum spathulatum</i>	R	-	-
-	-	<i>Laurencia papillosa</i>	C	-	-
-	-	<i>L. pedicularioides</i>	C	-	-
-	-	<i>Liagora cerenoides</i>	R	-	-
-	-	<i>Lophocladia lallemandi</i>	R	-	-
-	-	<i>Neurymenia fraxinifolia</i>	R	-	-
-	-	<i>Polysiphonia sp.</i>	C	-	-
-	-	<i>Rhodymenia australis</i>	C	-	-
-	-	<i>R. palmate</i>	C	-	-
-	-	<i>Scinaia indica</i>	C	-	-
-	-	<i>S. furcellata</i>	R	-	-
-	-	<i>Sebdenia polydactyla</i>	C	-	-
-	-	<i>Spyridia alternans</i>	C	-	-
-	-	<i>Soleria robusta</i>	C	-	-

Note: C=Common, R=Rare. Source: NIO

Table 16. Distribution of Corals in the Gulf

Species/Location	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>Esammocora digitata</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Acropora humilis</i>	-	-	+	+	-	-	+	+	-	-	-	-	-	-	-
<i>A. squamosa</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Montipora explanata</i>	+	-	+	+	-	+	+	-	+	+	+	+	+	+	+
<i>M. venosa</i>	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
<i>M. turgescons</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>M. hispida</i>	+	+	-	+	+	-	+	+	+	+	+	-	-	-	+
<i>M. foliosa</i>	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-
<i>M. monasteriata</i>	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-

<i>Coscinaraea monile</i>	+	+	+	+	+	+	+	+	+	-	-	-	-	-	+
<i>Siderastrea savigniana</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pseudosiderastrea tayami</i>	+	-	-	-	-	+	+	+	+	+	+	+	+	+	+
<i>Goniopora planulata</i>	+	+	-	-	+	+	+	-	+	+	-	+	-	-	+
<i>G.minor</i>	-	-	-	+	-	-	+	-	-	-	-	-	-	-	+
<i>G.nigra</i>	+	+	-	+	+	+	+	-	-	+	-	-	-	-	+
<i>Porites leutea</i>	+	+	+	+	-	-	+	-	-	-	-	+	-	-	+
<i>P.lichen</i>	+	-	-	-	-	-	+	-	+	-	-	+	-	+	+
<i>P.compressa</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Favia speciosa</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>F.favus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Favites complanata</i>	+	+	+	+	+	+	+	-	-	+	-	-	-	+	+
Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
<i>F. melicerus</i>	+	-	+	-	-	-	-	-	+	-	-	-	-	+	+
<i>Goniastrea pectinata</i>	+	+	+	+	+	+	+	-	+	+	+	-	+	+	+
<i>Platygyra sinensis</i>	+	+	+	+	-	-	-	-	-	+	-	-	-	+	+
<i>Hydnophora exesa</i>	+	+	+	+	-	-	-	-	-	+	-	-	+	-	+
<i>Plesiastrea versipora</i>	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Leptastrea purpurea</i>	-	-	-	-	-	-	-	-	-	-	-	Sikka point			
<i>Cyphastrea serailia</i>	+	+	+	+	+	+	+	+	+	+	-	-	+	+	+
<i>Symphyllia radian</i>	-	+	-	+	-	+	-	-	+	-	-	-	-	-	-
<i>Acanthastrea simplex</i>	+	+	+	+	-	-	-	-	+	+	-	-	-	-	+
<i>Mycidium elephantotus</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Paracyathus stokesi</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	10	m
<i>Polycyathus verrilli</i>	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-
<i>Tubastraea aurea</i>	+	+	+	+	+	-	-	-	+	+	-	-	-	-	-
<i>Turbinaria crater</i>	+	+	-	+	-	-	+	-	-	-	-	-	-	-	+
<i>T.peltata</i>	-	+	+	+	+	+	+	-	-	+	-	-	+	+	+

1 : Okha	2 : Dholio Gugar	3 : Dona
4 : Boria	5 : Mangunda	6 : Savaj
7 : Paga	8 : Manmarudi Langamarudi	9 : Ajad
10 : Bural reef	11 : Dhani	12 : Kalumbhar reef
13 : Narara reef	14 : Goose reef	15 : Pirotan island

Source: NIO, 2017

CONCLUSION

Study area comprise of sea shore and terrestrial habitat. Spatial extent and distribution of vegetation types can be linked to the human induced changes and biodiversity characterisation. None of the sighted animal species can be assigned endemic species category of the study area. Some of the animal observed in the study area is protected under schedule I and II have to be protected and not disturbed at all, for the same, the conservation plan should be implemented for entire life of the project as per suggestions in conservation and from forest officials. An urgent need of Mangrove Management plan to implement by authority is recommended for restoration of ecological balance of the area.

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