

Faunal Biodiversity Survey for Baseline Assessment of Gosabara Wetland Complex in Gujarat

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Faunal Biodiversity Survey for Baseline Assessment of Gosabara Wetland Complex in Gujarat

Authors

Bharatkumar Jethva, Chittaranjan Dave, Kiran Ahir, Dishant Parasharya, Mayurdan Gadhvi and Kangkan Jyoti Sharma

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Summary

As part of the Indo-German Biodiversity Programme (2012-to-2017), “Conservation and Sustainable Management of Coastal and Marine Protected Areas” (CMPA) project was implemented by Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India, and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The present study titled “Faunal Biodiversity Surveys for Baseline Assessment at Gosabara Wetland Complex, in Gujarat” was carried out by Green Support Services (between 16/11/2015 to 29/07/2016) as part of the above mentioned project. The present study was to conduct detailed ecological assessment surveys of insects, fish and other aquatic species, herpetofauna, water birds, terrestrial birds & mammals of Gosabara wetland. The study also involved assessment of current threats to the above ecological elements, identification of economically important, identification of threatened species, and other species of conservation significance, identification of invasive species, ecological analysis of the key species interactions and ecological significance in the wetlands.

Desk review of insects suggests that studies on insects for Gosabara Wetland Complex were carried out till date. We randomly sampled insects in winter (n=56) and in monsoon (n=108) seasons in agriculture, wetland & creek area and peripheral vegetation along the wetland. We reported insects belonging to total 6 orders, 13 families from Gosabara Wetland complex. From the observed insect's specimen, we could identify 18 of them species up to levels. One of the important group of insects found in Gosabara wetland complex are Odonates. The observed insects were occupying different feeding guilds such as omnivorous, herbivorous, saprophagus, nectorsuckers etc. The insects reported from Gosabara wetland complex are known to perform variety of ecological functions in eco-systems such as pollinators, pest, vectors, decomposers, dung feeders, prey/food for other insects and animals etc. The observed insects were occupying different feeding guilds such as omnivorous, herbivorous, saprophagus, nectorsuckers etc. The insects reported from Gosabara wetland complex are known to perform variety of ecological functions in eco-systems such as pollinators, pest, vectors, decomposers, dung feeders, prey/food for other insects and animals etc.

Study of fishes and other aquatic animals reported total 21 species belonging to 12 families from Gosabara Wetland complex. This included 3 species belonging to 2 families that are economically important crustaceans. The *Oreochromis mossambicus* has been assessed as Near Threatened species by IUCN because its population is threatened by hybridization with the rapidly spreading other species of same genus. We also observed Triops species and Clam Shrimp species during monsoon season from Gosabara Wetland Complex. There are two major communities, Muslims and Vaghri from 4-5 surrounding villages involved into fishing activity. Major fishing activities are seen at Kurly Creek, Gosabara, Vanana creek areas. Overall this wetland complex has preserved considerable fish and crustacean diversity (including Near Threatened Fish species) which could be as a result of its high nutrient supply from the catchment areas and good water quality without pollution and sewage maintained till date.

Study of amphibians observed 4 species of belonging to 4 genera and 2 families i.e. Bufonidae and Ranidae from Gosabara wetland complex. Out of these four, the most abundant species was Common Indian Toad (*Duttaphrynus melanostictus*) with relative abundance of 42% followed by Marbled toad (28.6), Indian Skipping frog (14.3) and Indian Bullfrog (14.3). All the four species were recorded from the wetland habitat and dry open land in surrounding area.

Study of Reptiles at Gosabara observed 16 species of reptiles, belonging to 14 genera and 9 families. Total reptilian fauna comprised of 1 species of turtle, 7 species of snakes, 3 species of lizards, 3 geckos and 2 species of skinks. The most abundant species recorded was Bengal Monitor Lizard (*Varanus bengalensis*) with relative abundance of 29% followed by Indian Garden lizard (*Calotes versicolor*) with 18% relative abundance. Indian Flapshell turtle, has been put under the appendix II of CITES and protected under Schedule I of the WLPA (1972), due to its heavy demand due to superstitious blind beliefs. Bengal Monitor lizard also belongs to Schedule I of WLPA (1972). Most of the species are listed as 'Least Concerned' or Not Evaluated categories by IUCN.

Study of birds was divided into study of waterbirds and terrestrial birds. The population of waterbirds was estimated on 31 January 2016 by dividing Gosabara Wetland Complex into 5 workable zones. Experienced bird enumerators were involved to identify and count number of birds in each zone. Waterbird population estimated was highest so far compared to previous estimation made by several agencies i.e. 3,79,382 birds. Higher number of the birds could be due to good rainfall during monsoon in 2015. During water bird study we observed a total of 120 waterbirds and water dependent bird species along with few terrestrial ones in Gosabara wetland complex. During our survey we reported the Gosabara wetland complex supports 1% populations of 32 species which is probably the highest by far in any wetlands of Gujarat. Gosabara wetland complex also fulfils another Ramsar Convention Criteria of supporting 20,000 or more birds. With such large concentration of waterbirds, Gosabara Wetland Complex qualifies to be notified as a wetland of international importance. Gosabara wetland complex is one of the most important wintering ground for two species of cranes. Of 112 species reported, 98 species are considered as Least Concerned as per IUCN category, where as 4 species are considered as Vulnerable and 10 species are found to be Near Threatened species. There was only one species i.e. Eurasian Spoonbill belonging to Schedule-I waterbird species as per Wildlife Protection Act 1972.

Using various survey methods we reported total 118 terrestrial bird species in Gosabara wetland complex. The number of species recorded during winter were 114 where as only 80 species were reported during summer season. Lesser number of species reported during summer could be due to higher temperature, high wind speed and lack of food and water in Gosabara wetland complex. We carried out point sampling counts to estimate species richness, diversity and density of terrestrial birds in Gosabara wetland complex.

Terrestrial bird surveys using various methods such as extensive search method, random point sampling, random encounters, as well as fixed spot sampling methods in Gosabara wetland complex we found total 118 species. The number of species recorded during winter were 114 where as only 80 species were reported during summer season. Lesser number of species reported during summer could be due to higher temperature, high wind speed and lack of food and water in Gosabara wetland complex. The overall terrestrial bird density differed significantly between two seasons [$40.3.1 \pm 3.8$ (SE) birds per ha. in winter and 28.9 ± 3.2 (SE) birds per ha. in summer] due to drying of water in Sumer seasons from Gosabara wetland complex. Apart from this the agriculture field also dries up during summer season and above all the migratory species are absent from this landscape during summer. The overall terrestrial bird species diversity index using Shannon Diversity Index was estimated to be 3.5 in winter (n=41) and 4.12 (n=41) in summer season in Gosabara wetland complex. The lower diversity of terrestrial birds in wetland eco-systems is naturally justified as the majority of the area is wetland or dry area in the Sanctuary. More over this area is open dry and saline landscape which has very low tree canopy which restricts distribution and presence of more number and diversity of terrestrial bird species. The Simpson Index for winter was 0.048 and 0.014 for summer suggesting no major differences in the diversity in two seasons. The species richness i.e. Margalef's Richness Index differed between two seasons as it was 7.3 in winter and 11.4 in summer season. Our survey results suggests that majority of the terrestrial birds recorded in Gosabara wetland complex to insectivorous birds 51.7%, followed by omnivorous birds 15.3%, carnivorous birds 13.6%, granivorous birds 13.6%, frugivorous 2.6%, insectivorous 1.7% and piscivorous 0.8% and scavenger birds were 0.8%

Total 14 species belonging to 11 families of mammals were reported from Gosabara wetland complex during surveys carried out in Decembe-2015 and January-May 2016. The population estimation of some of the large and conspicuous species such as Wild Pigs and Nilgai were carried out by dividing Gosabara wetland complex in to three major zones/blocks. Total 119 Nilgai individuals in winter and 127 individuals were recorded in summer. Relatively lower number of Nilgai found in winter could be due to their dispersal into surrounding fellow agriculture fields. The average group size of Nilgai was 7.0 ± 0.5 (SE) where as it reduced to 5.2 ± 0.5 in summer. The block counts carried out for Wild Pig population in Gosabara wetland complex reported total 161 wild pigs in winter and 136 individuals in summer.

Since Gosabara wetland complex is non-protected, there are several threats which we observed during out survey visits. One of the major threats is poaching of migratory and resident birds by local people which is often reported in local news papers. This activity in and around Gosabara wetland complex shall be curbed by keeping close watch on major roosting and congregation sites or waterbirds in wetland during every winter season. The illegal fishing activities are posing threat to waterbirds as they get entangled in to nets during nights and die. Dogs chasing waterbirds is also a major threat that we observed. During winter season, large flocks of waterbird particularly flamingo and crane which are known to fly during dark hours flies into powerlines around wetland. This often happens near Gosabara village where flamingo regularly move between coast and wetland.

BACKGROUND OF THE STUDY

Ministry of Environment, Forests and Climate Change (MoEF&CC), Government of India, and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH on behalf of the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB) are jointly implementing a project on “Conservation and Sustainable Management of Existing and Potential Coastal and Marine Protected Areas” (CMPA), of the Indo-German Biodiversity Programme between year 2012-to-2017. The project is being implemented in Gujarat, Maharashtra, Goa and Tamilnadu.

In the State of Gujarat, the project activities are implemented on the following project sites: Khijadiya Wildlife Sanctuary Jamnagar, Gosabara wetland and Madhavpur Turtle area Porbandar. In Gujarat, the project facilitates measures that result in the following outputs:

- Participatory processes for the management of areas identified for conservation of biodiversity have been implemented;
- A capacity development system for the sustainable management of coastal and marine protected areas has been made available in Gujarat;
- Relevant stakeholders are aware of – and sensitized for – the importance of conserving biodiversity in coastal and marine areas.

As part of the first output area in Gujarat, mentioned above, GIZ has commissioned several scientific and technical studies in Gujarat to assess the biodiversity, socio-economic, hydrological and climate change related parameters on the two project sites. Under this larger umbrella, the present study titled “Faunal Biodiversity Surveys for Baseline Assessment at Two Wetlands in Gujarat” was assigned to Green Support Services, based out of Gandhinagar, Gujarat. The study duration was 16/11/2015 to 29/07/2016. The main objective of the study was Characterization of faunal biodiversity of Khijadiya Wildlife sanctuary and Gosabara wetland complex to support their integrated management planning.

The requested services for this contract were

- 1) detailed desk study on the existing information, based on all possible sources of information, on the ecological characters and faunal biodiversity elements at the two sites i.e. Khijadiya Wildlife Sanctuary and Gosabara Wetland Complex,
- 2) develop 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: fish and other aquatic species, water birds, terrestrial birds & mammals in the nearby areas, reptiles and amphibians (herpetofauna), Insects and others

- 4) assessment of current threats to the above ecological elements assessed, on the two wetlands,
- 5) identification of economically important species at the two wetlands, based on current and potential use of these species by the local community,
- 6) identification of threatened species, and other species of conservation significance,
- 7) identification of invasive species of the wetlands, and conduct detailed populations studies of the most significant species,
- 8) 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.

In order to accomplish the above mentioned aspects, different renowned experts who have worked in these wetland areas or in the region on the respective aspects were engaged by Green Support Services. The study was conducted with due permissions obtained from the forest department (Annexure-II). The study results were not publicized in any media or any medium directly or indirectly.

HOW TO USE THIS REPORT

For the convenience of the authors, readers, managers and user agencies, this report is divided in to two major parts i.e.

Part-I: Faunal biodiversity survey of Khijadiya Wildlife Sanctuary &

Part-II: Faunal biodiversity survey of Gosabara Wetland Complex.

Further each part is divided into chapters corresponding to the tasks listed under the terms of reference. Details on each task of the ToR have been presented in the corresponding heading.

Desk Study

1. TASK- 1. DETAILED DESK STUDY

1.1. WETLANDS IN INDIA AND GUJARAT

India, with its varying topography and climatic regimes, supports diverse and unique wetland habitats (Prasad et al., 2002). Jheels (lakes), Talav (ponds), dams, seasonal waterbodies, paddy fields, streams, marsh lands, coastline, mangroves, coral reefs, estuaries and large stretches of mudflats etc. contribute significantly to enrich habitat diversity, resulting in rich wetland biota, including colourful bird life. Water is a basic and primary need for all vital processes in an eco-system. Therefore, wetlands are one of the most productive ecosystems and most severely affected habitats next to tropical forests. Wetlands are important elements of a watershed because they serve as the vital link between land and water resources. Wetlands play an integral role in the ecology of a watershed. Their shallow waters, nutrients, and primary productivity are ideal for organisms that form the base of the food web upon which many species of animals depend. Wetland habitat provides the necessary food, water and shelter for amphibians, reptiles, birds and mammals (Ghadigaonkar et al. 2015).

Wetlands are considered to have unique ecological features which provide numerous products and services to humanity (Prasad et al., 2002). Ecosystem goods provided by the wetlands mainly include: water for irrigation and other purposes; fisheries; non-timber forest products and recreation. Major services include: carbon sequestration, flood control, groundwater recharge, nutrient removal, toxics retention and biodiversity maintenance (Turner et al., 2000).

Space Applications Centre (2010) estimated about 1,50,174 sq. Km (6.9% of the total geographical area of the country) of wetlands in the country, with highest share of Gujarat amongst all states in India. Of this, 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). In other words, about one fourth of the India's wetlands are in Gujarat. The coastal and inland wetlands of Gujarat cover 35.8 % and 6.0 % of the total wetland area respectively in India. The state recognised the value of important wetlands related to geo-morphology, ecology, flora and fauna and constituted nine Protected Areas - one national park, seven sanctuaries and one conservation reserve to preserve a total area of 13,052 sq. km. Additionally, eight wetlands of national conservation significance have been identified and notified by the Ministry of Environment Forests & Climate Change (MoEF&CC), Government of India for their conservation in partnership with the local communities.

Gosabara wetland complex is one of the major wetlands of Saurashtra; Gujarat. One of the most important places for migratory birds and other water birds, Gosabara wetland complex is growing its popularity among the bird watchers, nature lovers and ecologists. Therefore it becomes a prime responsibility to know and record the present status of faunal diversity and its seasonal variation. Therefore present study was conducted as part of the project to discover the faunal biodiversity of Gosabara Wetland Complex. The purpose of survey is to give a brief overview of current insect diversity Gosabara Wetland complex.

1.2. DESK REVIEW OF INSECTS:

Insects among the arthropods are found in extremely diverse habitats throughout the world and constitute about three quarters of all living species on earth. Insects form the largest class of Phylum arthropoda. More than 5,000 species are reported from India. They are by far most valued in conservation for their ecological roles. They are the key component in the composition, structure and function of ecosystem (Hafernik, 1992; Ricklefs *et al.*, 1984; Wilson, 1987). They are abundant herbivores and detritivores influencing directly and indirectly elemental cycling and net productivity (Seastedt and Crossely, 1984). Distribution of insects in particular area may be regular, occasional, seasonal, persistent or sporadic. This can be determined by physical barriers like large masses of water for land insects, climatic conditions, biological barriers like food, existence of competitors and natural enemies. The sensitivity of insects to environmental conditions is proven to be useful for assessing an ecosystem conditions. Aquatic insects have been used as indicators of water quality. Ant, dung beetles and other terrestrial species have been used as indicators of success of ecosystem restoration.

According to estimates made by Z.S.I (1980), in India we have 67000 species of described insects. However the taxonomic knowledge of the group is still inadequate, particularly with reference to national parks and sanctuaries except in southern parts of India. But, overall the diversity of insect species is very vast and unexplored (Samways 1994). No systematic studies on insect have been carried out in Gujarat barring few isolated works on certain groups. Vazirani (1968, 1977) reported studied some water insects of Gujarat whereas Prasad and Varshney (1995) studied odonates species of Gujarat. Sabnis and Amin, (1992) recorded about 250 species of insects belonging to several orders from Narmada valley in Gujarat region during the faunal survey conducted during 1990 -1992. Butterfly fauna of Jessoré sloth Bear sanctuary was carried out by Suresh *et al* (2001). Parikh (2001) worked on Arthropods of Gir Protected and its surrounding ecosystem.

Fauna of arthropod pests infesting various crops of Saurashtra was reported by College of Agriculture, Gujarat Agricultural University, Junagadh (1995). Their list includes 198 species of insect pests. Insect studies in Gujarat are scanty in comparison to other Indian States (Ahir, 2005). Therefore, the need to know more about insect faunal wealth is great because of their small size and modest needs. Most insects and other invertebrates occupy ecological niches that are more numerous and smaller in dimensions (space, time and so on) and therefore more sensitive as compared to vertebrates.

Thus, studies on insects are by large scanty in Gujarat particularly for wetlands there are no substantial report available till date. Therefore, it is essential to study insect at Gosabara Wetland Complex and fill the lacuna for this particular aspect.

1.3. DESK REVIEW OF FISH

Fish occupy almost all major aquatic habitats. Inland fish play critical roles in the function of their ecosystems (Dudgeon *et al.* 2006). For example, predatory species, such as northern pike (*Esox lucius*) have significant impacts on fish

community composition (He and Kitchell 1990). Other fish species have been shown to alter the habitats in which they live, from herbivorous grass carp (*Ctenopharyngodon idella*) modifying aquatic vegetation (Wittmann et al. 2014). Fish impacts on habitat are not limited to the local scale; migratory fishes such as Pacific salmon (*Oncorhynchus* spp.) transport energy and nutrients to support distant aquatic and terrestrial food webs (Wipfli and Baxter 2010). When functioning properly, inland ecosystems provide many valuable services to people (i.e., provisioning, regulating, supporting, and cultural services; e.g., detoxification of wastes, management of infectious diseases).

Inland fishes account for approximately 40% of all fish species and 20% of all vertebrate species (Helfman et al. 2009). Biodiversity of inland fishes, at both species and population levels, also confers important benefits. When people rely upon functioning ecosystems for their basic needs, natural disasters and other disturbances to those ecosystems can be devastating. Natural ecosystems that recover quickly from such disturbances have resilience. Ecosystems with high species richness exhibit increased resilience (Downing and Leibold 2010), highlighting the importance of diverse inland fish communities. However, species assemblages are not the only factor moderating the impacts of disturbance on fish populations. A diversity of biologically relevant characteristics among fish populations of the same species (e.g., alternate life histories) also has been shown to improve resilience to perturbations (Schindler et al. 2010). Biodiversity confers benefits to aquaculture as well. Genetic diversity within species provides the building blocks for selective breeding and stock improvement, and enables the creation of transgenic fishes, such as genetically modified Atlantic salmon (*Salmo salar*) that grows more quickly and require less food than non-modified fish (Gjedrem 2000). The central role of inland fish in aquatic ecosystems makes them good indicators of ecosystem change. Inland fish are used as warnings for current and impending impacts on human well-being from environmental change. Beyond overfishing, aquatic ecosystems are faced with both direct and indirect anthropogenic influences that may have undesirable consequences. Threats from eutrophication, flow modification, destruction or degradation of habitat, and invasion by exotic species place 65% of freshwater habitats at risk (Dudgeon et al. 2006; Vorosmarty et al. 2010). The large scope of these threats arises because inland aquatic habitats are in close proximity to a variety of anthropogenic activities (e.g., agriculture, deforestation and hydropower) and because aquatic habitats integrate environmental influences throughout a watershed (Allan 2004).

Fish respond directly to some environmental stressors such as toxic and thermal pollution, flow regime change, and climate change (Dudgeon et al. 2006). Around the globe, inland fish populations and species assemblages often indicate changes in nutrient inputs to their watersheds (Ludsin et al. 2001). Inland fishes respond to many aquatic and terrestrial environmental changes throughout their watersheds, making them valuable bioindicators of ecosystem health.

Inland waters are defined by the Food and Agriculture Organization of the United Nations (FAO) as lakes, rivers, streams, canals, reservoirs, and other land-locked waters (FAO 2014). While inland is generally synonymous with freshwater, inland waters do include land-locked saline water bodies such as the

Caspian Sea (FAO 2014). Inland waters comprise approximately 0.01% of the total volume of water on earth. Inland fishes reside in these waters. They comprise approximately 40% of all fish species and 20% of all vertebrate species. However, the difficulty in assessing aquatic biodiversity, particularly in developing countries and remote areas, suggests that inland fishes are more diverse than the reported estimates (Cooke et al. 2012). Additionally, 65% of inland habitat is classified as moderately or highly threatened by anthropogenic stressors (Vorosmarty et al. 2010), so populations may be extirpated even before they are documented. Inland fish species are present in almost every inland ecosystem on earth. These inland fishes also serve as indicators of ecosystem function and ecosystem change (Allan 2004).

The Indian subcontinent, occupying a position at the confluence of three biogeographic realms, viz., the Palaearctic, Afro-Tropical and Indo-Malayan, exhibits a great variety of ecological habitats harbouring rich ichthyo faunal diversity. The contribution to the global fish community is about 3500 species and out of which there are 2500 species recorded in the subcontinent. The Indian species represent about 8.9% of the known fish species of the world.

In the world's biological resources, India is one of the 17 mega biodiversity hot spots contributing with 60-70 % and having third rank in the world in total fish production with the contribution of 11.72% of total global fish biodiversity (Kumar, 2012). Out of the total 2500 species from India, 930 species are freshwater inhabitants. Devi and Indra (2012) in an annual report by Zoological Survey of India have reported 667 species grouped under 12 orders, 35 families and 149 genera.

An annual report by Zoological Survey of India, Devi and Indra, 2012 reports about 120 freshwater fishes are found in Gujarat state. According to books by authors A.D. Dholakia (Fisheries and Aquatic Resources of India, 2005), Patel and Chhaya (1979) (Field key to fishes of Gujarat,), a total of 96 freshwater fishes are present in the state of Gujarat. The other major literature resource available for freshwater fishes indicates work done by Goswami and Mankodi (2010) and Gohil and Mankodi (2013) on Nyari-II reservoir and Mahi River where they found fifteen and twenty six species of fishes respectively.

In case of Gujarat, the fishermen community mostly deal with marine fishes as they find a large exposure area of catch in respect to the freshwater fishes so there is very less document or biodiversity work available for freshwater fishes in this state.

1.4. DESK REVIEW OF HERPETOFAUNA

Herpetofauna include amphibians and reptiles. Reptiles and amphibians occupy a diverse range of habitats and microhabitats, found from deserts to grasslands, from forests to oceans and from hills to our own houses. About 9,596 known species of reptiles and 6,000 species of amphibians are known worldwide, of which, 518 reptiles and 314 amphibians inhabit India and 107 reptilian species and 22 amphibian species occur in Gujarat (Vyas 2007). Reptiles and amphibians (collectively called herpetofauna) constitute important elements of biotic components of various ecosystems because they occupy various niches (like arboreal, aquatic, terrestrial and fossorial). There are more than 6,000 currently recognized species of extant amphibians, with representatives present

in virtually all terrestrial and freshwater habitats, but absent from the coldest and driest regions, and from the most remote oceanic islands. The number of recognized species of amphibians has grown enormously in recent years, with a nearly 50% increase between 1985 and 2004 (Frost 1985, 2004) and an increase in species numbers of 25% in the years between 1992 and 2003 (Köhler et al. 2005). This unprecedented growth largely reflects an increase in collecting work in previously remote locations, a significant growth of active herpetological communities in a few mega diverse countries, and the application of complementary techniques, such as molecular genetics, to support more traditional taxonomic methods.

Amphibians are ecological indicators and in recent decades there has been a dramatic decrease in their populations. Many species are now threatened or extinct. Amphibians are the least amongst the vertebrates and comprise nearly 6.6% of the total vertebrate life on the earth. Total number of species in the world has been estimated around 3,140 and in India 214 species are known. However Dinesh et al. (2011) has mentioned 314 species of amphibians in India. According to IUCN criteria 57% of the amphibians in India are 'threatened' (Vasudevan et al., 2001). Reptiles are diverse in south Asia with approximate 632 species belonging to 185 genera and 25 families. India harbors 456 species of reptiles belonging to 25 families and 4 orders including 3 species of Crocodilia, 31 of Testudines, 178 of lizards and 244 species of serpents.

In Gujarat, a number of studies have been carried out on reptiles in the post independence era (Acharya 1949; Kapadia 1951; Sharma 1982; Gayen 1999) adding about 48 species of reptiles (Vyas 2000). Excluding the protected areas Vyas (1993) studied the snakes of the Gujarat State. A total of 107 species of reptiles belonging to 21 families were reported by Vyas (2000). Naik et al (1993) gave a comprehensive account of the amphibian distribution in Gujarat. They gave distribution of about 15 species of amphibians in the state; however the majority of their inferences were confined to the collections presented at BNHS and / or ZSI. Vyas (2004) reported 9 species of amphibians from the Barda Sanctuary, which is the nearest study from the Gosabara Wetland complex.

An endemic gecko *Hemidactylus porbandarensis* (Sharma, 1982) described from Porbandar is a synonym of *Hemidactylus robustus* Hayden 1827 (Bauer et al. 2012). The studies emphasizing on the importance of the herpetofauna in the wetlands and wetland complex are rare with reference to Gujarat and requires detailed ecological studies.

1.5. DESK REVIEW OF BIRDS

The Gosabara wetland complex is a group of wetlands incl. Medha creek, Kuchhadi, Subhashnagar, Zavar, Karly I, Karly II, Vanana, Dharampur, Gosabara, Bhadarbara, Mokarsagar, Bardasagar and Amipur of Porbandar district of Gujarat. This wetland is surrounded by several villages such as Miyani, Visavada, Palkhada, Modhvada, Kuchhadi, Zavar, Chhaya, Odedar, Ratanpar, Vanana, Ranghavav, Bhorasa, Dharampur, Gosa, Narvai, Bhad, Lushala, Navagam, Tukda, Mokar, Amipur, Chikasa and Pipliya of Porbandar district. Vargiya et al. (2015) has explicitly explained geo-morphology, drainage, connectivity, birdlife and related conservation issues of Gosabara wetland complex.

A local NGO called 'Mokarsagar Wetland Conservation Committee' has reported a checklist of total 123 species of birds in and around Gosabara wetland complex on their website. Gadhvi (2014) conducted a first ever comprehensive bird count for this entire wetland complex and reported total 118975 waterbirds from Gosabara wetland complex. The Mokarsagar Wetland Conservation Committee has been monitoring this wetland bird since 2015 onwards. Keeping in view the importance of this wetland, local conservationists and Government of Gujarat has been thinking of protecting this wetland using one of the protected area forms under the Indian Wildlife Protection Act 1972. There was a public interest litigation also filed in favor of designating it a wildlife sanctuary status. However, due to several socio-political reasons it has not materialized yet. Gosabara wetland complex has been in local news highlighted since last 2-3 years because of its bird population congregation, illegal fishing activities, calling for a fishing ban, poaching of birds and related socio-political issues.

No other systematic study has been carried out on waterbird assemblage of Gosabara wetland complex till date. In the present study we made effort to understand the bird diversity of Gosabara wetland complex. Since waterbirds and terrestrial birds are studied using different methodology, we divided study of birds into two separate parts i.e. study of water birds and study of terrestrial birds.

1.6. DESK REVIEW OF MAMMALS

Management and conservation of any ecosystem requires information on species assemblages as well as reliable estimates of population sizes of its major components such as birds, mammals etc. As per revised and updated checklist of Indian Mammals (Nameer, 2008), India is providing habitat to 417 mammals species. Zoological Survey of India (ZSI 2004) has reported 12 Orders, 33 Families, 68 Genera and 101 Species from Gujarat. There are numerous techniques being used for survey of mammals. Due to differential detection probability coupled with their habits such as diurnal and nocturnal, it is difficult to use one approach to study all mammals in any eco-system. Therefore, suitable techniques are required to be used for studying mammals in heterogeneous landscapes such as wetland.

Detailed Methodology

2. TASK-2. DEVELOP DETAILED METHODOLOGY

During study, following methodology was developed and used for each of the component of study such as Insects, Fish, Herpetofauna, Birds and Mammals.

2.1. DETAILED METHODOLOGY FOR INSECTS

Class insecta is considered as the largest class of arthropoda. Identification of insects is fundamentally not different from Identification and quantitative analysis of birds, mammals, fishes and amphibians. However, their size, lifecycle and drastic change in appearance and habits throughout their life cycle make it difficult to identify (Borror and white 1970). For many species rich insect taxa it is monumental task to collect all species from a site. Moreover, it is a far from trivial exercise to know what proportion of a site's fauna has been sampled as a function of collecting efforts and methods (Brown and Feener 1995, Colwell and Coddington 1994, McGowan 1996). Each stage of lifecycle of an insect varies in their size, shape, colour, food, habitat and behavior. The lifecycle stages of different insects differ from few months to several years. Some insects even take 17 years (Cicada) to accomplish their lifecycle. Therefore to obtain an accurate population data one requires at least two to three years of intensive sampling efforts. Therefore with given time and efforts in the current study, we inventorized a checklist of insects up to family, orders and species of insects of the Sanctuary. Following methodology was used for studying insects in Gosabara Wetland complex.

A reconnaissance survey was conducted in December 2015 through the entire stretch of the study sites to select the habitats and sampling sites. We used stratified random sampling approach for studying insects in the study area. Three broad habitat types were selected for Gosabara Wetland complex for insect study. The random sampling was carried out at total 56 sites in winter and 108 sites in monsoon using various methods such as beating umbrella, litter shifting, bark scarapping, sweep net, strainers etc. (Table-2.1). Insect captured were identified with slandered reference book up to family level and release back to their natural habitat. Photographs were also taken which helped to identify certain well known insects till species level. In order to study insects, following popular methods were used. The actual filed survey schedule, date-wise is provided in Annexure-I.

Table-2.1: Sampling effort in different habitats and season during the study.

No	Habitat	Sample points	
		Winter	Monsoon
1	Agriculture fields	19	37
2	Wetland & creek area	19	39
3	Peripheral vegetation	18	32
	Total	56	108

Sweep net: Sweep net was used for capturing flying insects and also insects found on vegetation. This method was mainly used studying large size and flying insects such as butterflies, mayflies, odonates etc.

Beating Umbrella: This method was used to gather insect fauna from taller vegetation such as tree canopy, shrub etc. During this method an umbrella is held upside down and the tree canopy is bitten gently with a stick to collect insects. The insects fallen in umbrella are collected in vials and identified.

Litter sifting: In order to study ground dweller and foliage feeder insects from the litter we used this method. The litter is shifted or lifted from the ground to expose the insects beneath.

Bark scraping: This method is especially used to studying borers and insects hiding under the bark of the trees. The bark of tree is gently scraped to expose and collect the insects.

Strainers: In order to study aquatic insects, we used strainers. Flowing and static waters from different depth were strained to collect insects.

Light trap: Light traps, were arranged to attract certain insects. Light sources like halogen lamps were used. Light traps are widely used to survey nocturnal moths and other nocturnal insects.

Direct photography: During studies of insects were photographed in their natural habitats without disturbing them. Macro SLR lenses were used to take good quality pictures of insects which were further used for identification with help of standard reference books.

2.2. DETAILED METHODOLOGY FOR FISH

The contract required detailed ecological study including diversity and population studies; however, there were several limitations related to the legal fishing ban in Gosabara wetland complex by the local administration, low water level and very low abundance of fish in areas where sampling was possible. Due to these factors population surveys of fishes was not possible. Therefore, we relied on qualitative method to study the species richness of fish in the study area.

During our field visits in monsoon we also collected the specimen by manually fishing using mosquito net in all the sites. For small fish species we used flowing water straining method. During monsoon/post monsoon several channel of water were flowing in the wetland complex. We put mosquito nets into flowing channels to catch small fishes and crustaceans for sample collection and photography. During these sampling efforts we mostly found fish fingerlings & fish fry along with very few small fishes which we could identify. Therefore, fingerlings and fish fry could not be identified up to species reliably. We photographed most of the fish and prawn specimens in order to preserve their actual colour and morphology. We collected samples, which ever required, and preserved them in plastic bottles containing 70% ethanol (Kumar and Hasan, 2015) and brought back to the laboratory and were properly identified using standard identification keys (Day, 1878, Froese and Pauly 2017). The actual field survey schedule, date-wise, is provided in Annexure-I.

Based on field observations, we compiled a list of fish and prawn species in the Gosabara wetland complex with their family names, scientific names, local names and common English names and their IUCN status. We collected information on fishery techniques and community associated with them. We also carried out interviews of total 18 fishing families and gathered information on fishing communities, fishing techniques, active fishing periods, fish catch/day, economically important fish species, average income per family etc.

2.3. DETAILED METHODOLOGY FOR HERPETOFAUNA

The contract required detailed ecological study including diversity and population studies, however, there were several limitations related to low abundance and detection probability of herpetofauna in the study area. During our survey efforts with great difficulties we encountered few herpetofauna species. Therefore, such low detection probability was a limitation for not conducting systematic population and diversity studies. Moreover, actual population assessment techniques call for intensive effort using capture-mark-recapture techniques or a complete census over one or more years (David *et al.* 2013). Population counts typically involve a series of surveys, with the peak count of each species being used (David *et al.* 2013). Peak counts are difficult to defend statistically, as they do not take account of variations in detectability from site to site. They can therefore be misleading (David *et al.* 2013). Therefore, with given low detection probability coupled with limited time and efforts available, we carried out simple surveys i.e. presence absence surveys to inventories the herpetofauna of the Gosabara wetland complex, the methodology was divided into following three parts.

Direct Search Method: In this method, we selected total 3 general broad habitat types viz. Wetland area and its fringes, wetland roads and surrounding dry wastelands and agriculture lands in immediate surroundings to assess the herpetofauna within the study area. These areas were randomly and intensively searched. All the habitats were repeated twice in a day i.e. once during the morning 7 to 11 am and during night 9 pm to 1 am, for 8 days by three persons separately. Total number of field work days scheduled for this site was 8 days. Therefore, 4 days sampling was carried out in winter season and another 4 days sampling was carried out by two persons (total 8 man days) in monsoon season. The actual field survey schedule, date-wise, is provided in Annexure-I. The main reason for this was to inventory the nocturnal fauna also. Uniform efforts were made in all habitats during surveys in day and night hours. All the species encountered were identified and photographed using Nikon D70 / D90 DSLR cameras. Relative abundance of the species was estimated based on the number of individuals occurred within the sampling area.

Straining water method: Straining of flowing as well as stagnant water was also carried out during monsoon season, however no amphibian or reptile was encountered in this method.

Indirect evidences: Both the wetlands were searched thoroughly to check the indirect evidences of the herpetofauna such as skin, body parts etc.

Consultation with the local experts: Local experts and naturalists, who visit the area frequently, were also consulted and data was obtained from them regarding the presence and absence of various herpetofauna species.

Calculations of Relative Abundance: Relative abundance of herpetofauna was calculated using method described by Michael (1986) with following formula.

Relative Abundance RA

$$= \left(\frac{\text{Total population of the species}}{\text{Total population of community}} \right) * 100$$

2.4. DETAILED METHODOLOGY FOR WATERBIRDS

Waterbirds are a key part of wetland ecosystems. Their presence, numbers and trends at a site can indicate the health and quality of a wetland. Waterbirds have an important social function, providing food, recreation and tourism opportunities. Waterbirds connect wetlands and people across cultures and borders; they are a shared wonder of the natural world. Therefore, it is important to monitor waterbird populations in wetlands. Waterbirds have been defined as “species of bird that are ecologically dependent on wetland. Waterbirds are well-known indicators of the quality of certain types of wetlands. A powerful tool which makes use of this characteristic is the so-called 1% criterion, whereby any site which regularly holds 1% or more of a waterbird population qualifies as a wetland of international importance under the Ramsar Convention on Wetlands. Waterbird Population Estimates by Wetlands International (2006) is widely used for calculating 1% geographic populations of waterbirds across the world (Li et al, 2009). It is also used by Birdlife International in the identification of Important Bird Areas (IBAs) in wetlands throughout the world. Various approaches can be employed to assess Waterbirds species composition and abundance over an area of interest, from total counts of all individuals present (a complete census) to sampling strategies that provide population estimates that can be extrapolated over the entire study area.

Population estimate: We used complete census method by dividing entire wetland in to different workable/accessible zones and counting/estimating waterbird species within each zone. The goal of a complete census is to conduct a total count of all the birds present over a specified area to obtain an unbiased estimate of abundance without statistical inferences or underlying assumptions. A reliable census is conditional on the assumption that all individuals present in an area can be recorded; therefore, censuses are most useful for conspicuous species occupying discrete and well-defined open landscapes and habitats. Some situations in which a reliable census may be possible include complete counts of waterbirds frequenting open wetlands. Experienced counters can accurately estimate 10, 20, 50, 100 or more birds almost instantaneously, and scan through flocks counting in these units with a tally counter. A complete census is more practical when targeted at large and conspicuous species especially where there are active networks of participants to undertake the work. This kind of approach is promoted for periodic waterbird census by organizations such as Wetlands International/IUCN etc. (Worden et al. 2006).

Waterbird Estimation in Gosabara wetland complex was carried out twice i.e. 29-30 December 2015 and on 28-29 January 2016. The first estimation was carried out to get primary estimate of the birds in Gosabara wetland complex. However, the second estimate was final estimate made on 28-29 January 2016. For this entire Gosabara wetland complex was divided into total 5 different workable zones (Map-2.1) which are as under. These zones covered almost 80% of the total wetland.

- a) Karli wetland- zone
- b) Dharampur- zone
- c) Vanana- zone
- d) Oddar- zone
- e) Mokarsagar- zone

During this estimation, experienced local birdwatchers that are good in bird identifications and those acquainted with the geography of the different zones were involved. Initially an introductory and orientation session was conducted to refresh the methodology of estimation data reporting. Following persons carried out estimation in Gosabara wetland complex in different zones. Bird counts were made with the help of spotting scopes and binoculars. Each team was instructed to carryout bird counts between 6:00AM to 9:00 AM.

- a) Bharat Jethva
- b) Dr. Virag Vyas
- c) Mr. Dhaval Varagya
- d) Mr. Bhaskar Thanki
- e) Ms. Harsha Hinglajia
- f) Volunteers of Mokarsagar Wetland Conservation Committee

Map-2.1: Different zones for waterbird Estimation in Gosabara wetland complex.



Waterbird Species Richness: During each field visits to Gosabara Wetland Complex; we recorded the sightings of the waterbirds in different habitats i.e. freshwater areas, mudflats, creek, agriculture areas etc. These sightings were used to prepare a comprehensive checklist of waterbird species reported in the Gosabara Wetland Complex and its surrounding areas.

2.5. DETAILED METHODOLOGY FOR TERRESTRIAL BIRDS

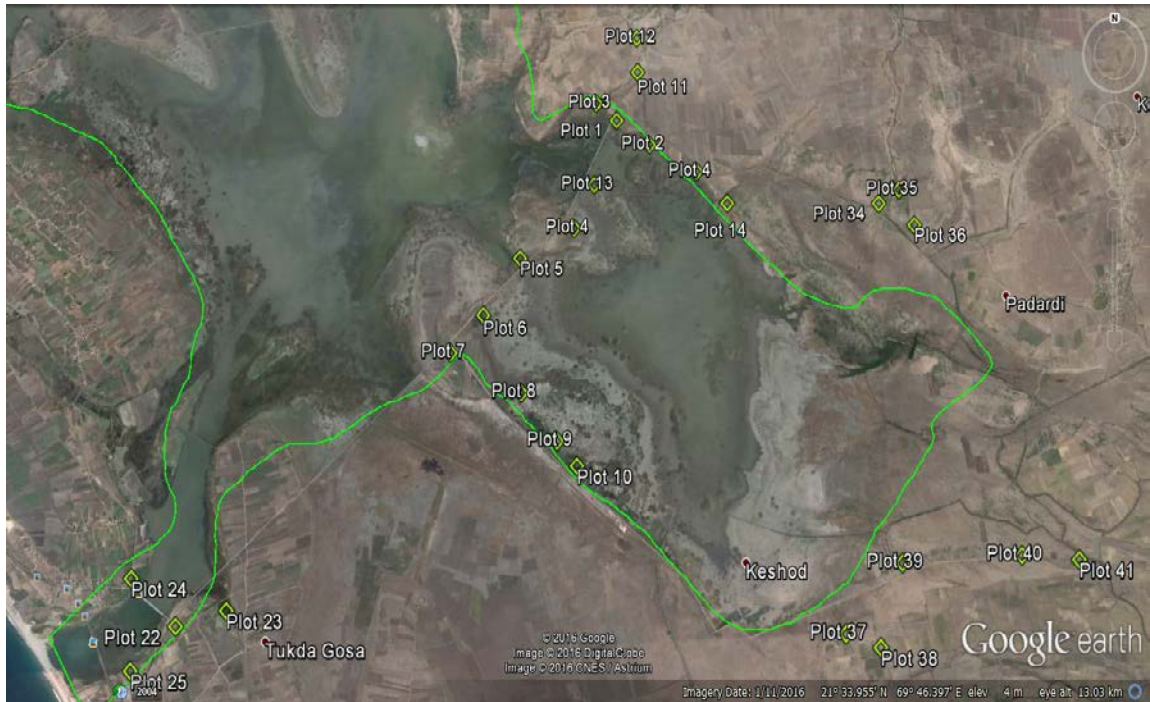
In order to study bird diversity and abundance in Gosabara wetland complex, we employed three methods i.e. 1) Random point count method, 2) Area Search Method or extensive search using roads and 3) Fixed spot sampling. The terrestrial bird surveys were carried out on in winter (December) 2015 and in Summer March-April 2016. During these surveys, Dr. Chittranjan, our team members, and some of the expert local birdwatchers were involved in sampling efforts. Total 2-3 birdwatchers other than the expert were trained in sampling efforts prior to actual sampling carried out in the field. Data were recorded and analysis was carried out to get preliminary results for this site. Different methods and efforts made are described as under. The methodology used are easy to repeat which would provide basic and most important information for managers i.e. species richness, species density, and diversity of terrestrial birds.

Random point count: method was used to quantify the density of various terrestrial birds in study area. Sampling is carried out at random locations in the study area. All the species found in a fixed 30 mtrs radius plot are recorded for not more than 4 minutes. This quick window sampling in different locations enables us to correctly report the bird species present in the habitat. We sampled at 41 random points in Gosabara wetland complex in winter and same points were repeated in summer (Map-2.2 a&b). The data collected are used to obtain quantitative estimates of bird species diversity and density etc.

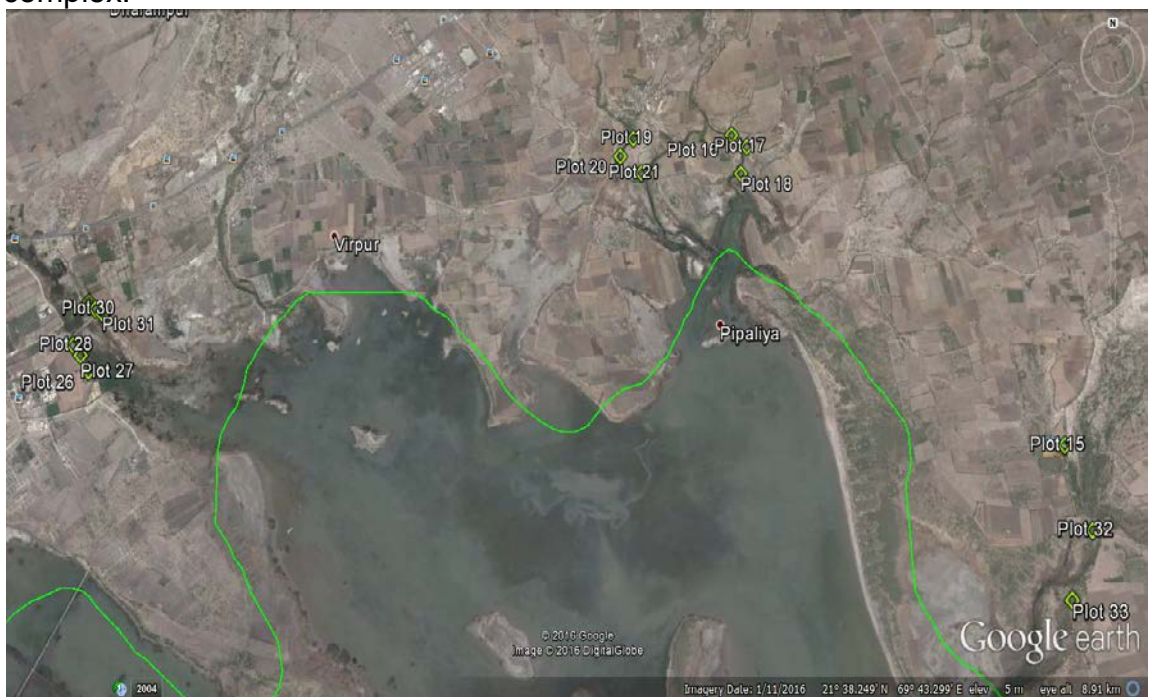
Extensive Search Method: is a qualitative method being used for improving the total species richness for each site in totality. In this method we slowly drive through the roads and look for birds and their calls. We identify birds based on their calls, colour etc. using binoculars and standard reference books. The species checklist for each site is prepared based on this method. Total 545 km in Gosabara wetland complex in winter and 345 km in summer were covered through drives on the cross roads in order to report the bird species seen during this period.

Fixed spot sampling: is a qualitative method which was used for improving checklist from different habitats. This method involved standing at one location for 10 minutes and reporting all the bird species seen from the pre-identified spot. The spots are identified based on different habitats in order to cover all types of habitats present in the site. Total 6 such fixed locations were chosen in Gosabara wetland complex (Map-2.3). The bird species were seen during these efforts were recorded and used for improving information on species richness in the overall sites. Since study area is primarily a wetland, we restricted our sampling efforts to wetland peripheries, roads, and on land forms present inside wetlands.

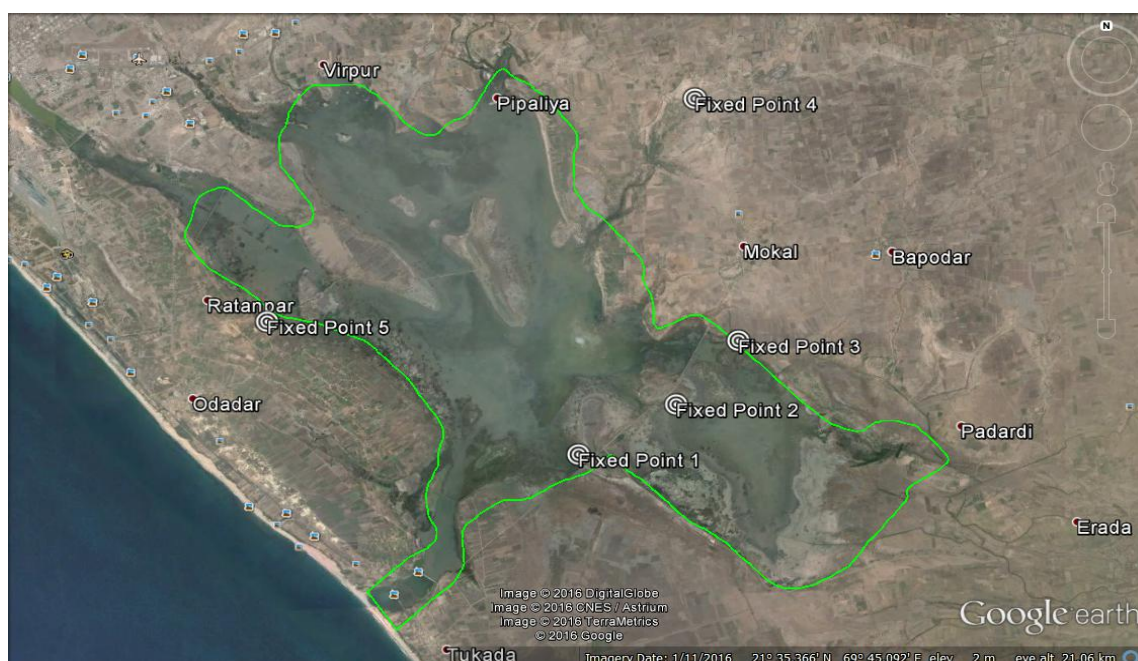
Map-2.2a: Random Point Count sampling locations in Gosabara wetland complex.



Map-2.2b: Random Point Count sampling locations in Gosabara wetland complex.



Map-2.3: Locations of fix spot sampling in Gosabara wetland complex.



Biodiversity Estimation:

We estimated α -diversity of terrestrial bird species within Gosabara Wetland complex. We used Shannon–Wiener diversity index, Shannon and Wiener (1949), Simpson Diversity Index, Simpson (1949), and Margalef's Index (Margalef, 1958). Following are details of the biodiversity indexes we calculated for terrestrial birds of Gosabara Wetland complex. We calculated these indices using XL spreadsheet as well as an online tool (www.ayoung.com) for quick and easy calculation of various biodiversity indices. Details of each of the indices are given as under.

Shannon Wiener Diversity Index: It is the most preferred index among the other diversity indices. The index values are between 0.0 – 5.0. Results are generally between 1.5 – 3.5, and it exceeds 4.5 very rarely (Kocataş 1992). The values above 3.0 indicate that the structure of habitat is stable and balanced; the values under 1.0 indicate that there are pollution and degradation of habitat structure.

$$H' = -\sum [(n_i / N) \times (\ln n_i / N)]$$

H' = Shannon Diversity Index

n_i = Number of individuals belonging to i species

N = Total number of individuals.

Simpson's index: The Simpson's index used is $D = 1 / \sum (p_i)^2$ where, " p_i " proportion of " i th" species and is calculated as " n_i/N ", where, " n_i " is the number of individuals in " i th" species and " N " is the total number of individuals in the sample but the form of the index used in the present study is:

$$D = \sum [n_i(n_i - 1) / (N(N - 1))]$$

N_i = the number of individuals in " i th" species

N = the total number of individuals in the sample

Margalef Diversity Index: It is a measure of species richness. It has no limit value and it shows a variation depending upon the number of species.

$$d = (S-1) / \ln N$$

d=Margalef Diversity Index

S= Total number of species

N= Total number of individuals

2.6. DETAILED METHODOLOGY FOR MAMMALS

During mammal diversity survey in Gosabara wetland complex, we initially used several techniques such as transect method, camera trap method for studying their diversity and density in these wetlands. However, due to their very low abundance, differential activity periods and clustered distributions these methods did not work. Since the presence of mammalian species is low affecting probability of their sightings, in the study areas, it was difficult to estimate their population using line transect method. More importantly, it was also difficult to accommodate the sightings of nocturnal and diurnal animals in the study. Therefore, we used following approaches to study their species richness and abundance in these ecosystems.

Random Observations: This method involves preparation of a qualitative check list of mammals based on direct and indirect observations during field work in the study area. We used all the direct and indirect observations on the presence of mammal species during each field visits.

Specific Habitat Search: search efforts were also made in various different micro habitats to gather direct and indirect evidences such as various signs of important habitat specific mammal species in the study area. This includes looking for signs such as footprints, dens, diggings, scrap marks, droppings etc. The micro habitats, where likelihood of animals is higher such as shady trees, waterholes, dense and undisturbed bushes etc. were surveyed intensively during the survey in the study area. This survey has helped us in identifying various mammal species, their behavior and characteristics. For mammal inventory, both direct sightings and indirect evidences (like dung, scats, pellets, foot prints, nests, dens etc.) were accounted.

Howling Surveys: Some of the canids that utilise howls to communicate, the response rate to simulated vocalisations has been used as an index of relative abundance (e.g., Wenger and Cringan 1978; Okoniewski and Chambers 1984; Fuller and Sampson 1988). Howling surveys typically employ recorded vocalisations, although human imitation can be used.

We tried to survey presence of their numbers in these wetland eco-system and their surrounding areas. Dr. Bharat Jethva specializes in vocal simulating howling of Indian Wolf and Jackals produced howling calls from elevated points. After each howling calls, we waited for 10 minutes to listen to the responses. Howling surveys were made from specific elevated locations from these wetlands between 8:30 to 10:00 PM in Gosabara wetland complex. Surveys were conducted over 6 nights using the vocalisation response to determine their presence. These surveys were helpful in determining presence and absence of canid species and also estimating their numbers to some extent.

Block Counts: As mentioned earlier, it was difficult to estimate population of mammals in these wetland eco-systems. Therefore, we used block count method to estimate population of some of the conspicuous diurnal mammals in Gosabara wetland complex. In this method entire area was divided into three workable zones based on their accessibility and manpower available with us. These zones are as mentioned below (Map-2.4).

Zone-1: Mokal zone

Zone-2: Ratanpar-Odadar zone

Zone-3: Vanana-Dharampur zone

Map-2.4: Different zones for block counts of mammals in Gosabara wetland complex.



Interview Surveys: There are several mammalian species which are very shy or have seasonal occurrences in the landscapes. In order to accommodate such species we also interviewed local cattle herders, fishermen, forest personals, local naturalists and other local people who we encountered in and around study area. Total 26 individuals in Gosabara wetland complex were interviewed for confirming the presence of various mammals they might be aware of. We showed them photographs of various animals to confirm their identifications and knowledge. These respondents also provided us people's perspective about the presence of wildlife species and their interactions with local community.

Camera trap surveys: In order to detect nocturnal animals, we carried out camera trap surveys in Gosabara wetland complex. During our field surveys, we laid camera traps at 10 strategic locations (trails, dense bushes, roads, waterholes) in Gosabara wetland complex for two times in winter and summer seasons. However, due to low abundances of nocturnal mammals, we did not find any mammals in camera trap except Wild pigs and Nilgai one time each.

Detailed Ecological Assessment surveys

3. DETAILED ECOLOGICAL ASSESSMENT SURVEYS

3.1. STUDY OF INSECTS

3.1.1. GENERAL OBSERVATIONS

During winter visit at Gosabara Wetland complex the least insect were observed as per diversity and density as well. Order Odonata, order Coleoptera, order Lepidoptera, order Diptera and order Hymenoptera were recorded during the survey. Odonata members were seen near human settlement. From order: Coleoptera three families were observed Scarabaeidae, Staphylinidae and Tenebrionidae. Lepidoptera was represented by single family Pieridae. Family: Mucidae and family: Culicidae were the families from order Diptera present at study area during winters. Ants; family: Formicidae were the only representative from order Hymenoptera. Overall during winter visit insect activities were too less and so was the appearance of insects.

Monsoon provided quite favourable conditions and supported the insect life in and around Gosabara wetland complex. Order Odonata, was the most dominating insect order by number of the individuals from this order were plenty. Total three families Aeshnidae, Libellulidae and Coenagrionidae were identified from the same Odonata. Presence of Hemiptera was also noticed two families Gerridae and Lygaeidae. Order: Coleoptera was the most diverse group of insect during this season four families were identified from this order; family: Scarabaeidae, was observed Staphylinidae on decaying vegetation near the water body, Tenebrionidae were mostly found under the dung, Chrysomelidae and Curculionidae. Three families from order Lepidoptera were recorded; family: Pieridae, Nymphalidae and Lycaenidae. Mucidae and Culicidae were the families of order: Diptera during monsoon. Hymenoptera was recorded with single family: Formicidae.

3.1.2. CHECKLIST OF INSECT FOR GOSABARA WETLAND COMPLEX

Class: Insecta

1. Order: Odonata

Suborder: Anisoptera

i. Family: Aeshnidae

Hemianaxephippiger (Burmeister, 1839)

ii. Family:

Brachythemis comtaminata (Fabricius, 1793)

Crocothemis servilia

Orthetrum Sabina (Drury, 1770)

Trithemis kirby (Selys, 1891)

Sub order: Zygoptera

iii. Family: Coenagrionidae

Ischnura senegalensis (Rambur, 1842)

Pseudagrion decorum(Rambur, 1842)

2. Order: Hemiptera

- iv. Family: Gerridae
- v. Family: Lygaeidae

3. Order: Coleoptera

- vi. Family: Staphylinidae
- vii. Family: Hydrophilidae
Hydrophilusolivaceus(Fabr)
- viii. Family: Scarabaeidae
Coprisnuma(Gillet)
- ix. Family: Tenebrionidae
Rytinotaimpolita
- x. Family: Chrysomeloidae
- xi. Family: Curculionidae

4. Order: Trichoptera

5. Order: Lepidoptera

- xii. Family: Pieridae
Euremahecade (Linnaeus)
Catopsiliapyranthe(Linnaeus)
Colotisdanae (Fabricius)
Colotisetrida (Boisduval)
Ixias Marianne (Carmer)
- xiii. Family: Nymphalidae
Danausgenutia(Cramer)
Danuschrysippus(Linnaeus)
- xiv. Family: Lycaenidae
Psuedozizeeria maha (Kollar)
Everes argiades (Pallas)

6. Order: Diptera

- xv. Family: Mucidae
Muscadomestica (Linnaeus)
- xvi. Family: Culicidae

7. Order: Diptera

- xvii. Family: Formicidae

Figure-3.1: Composition of insect families in Gosabara during winter 2015.

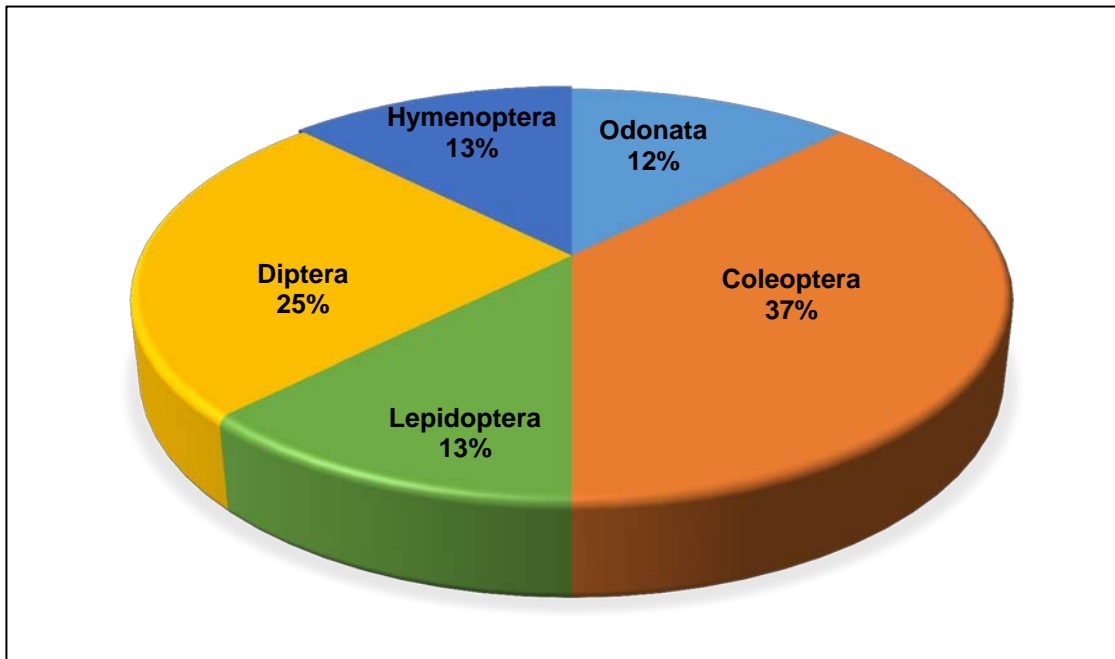
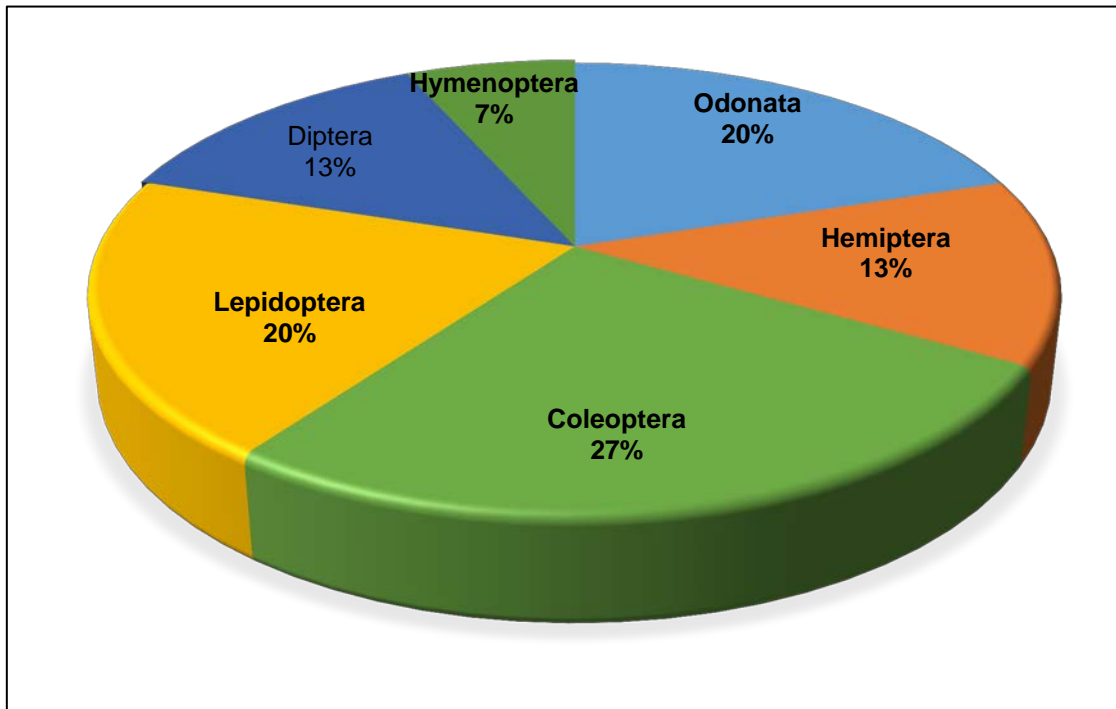


Figure-3.2: Composition of insect families in Gosabara wetland during monsoon 2016.



3.1.3. DISCUSSION AND CONCLUSION:

Present study has made an effort to evaluate insect species richness in Gosabara wetland complex. We reported total 6 orders, 13 families and 18 species from Gosabara Wetland complex. One of the important group of insects found in Gosabara wetland complex are Odonates. They spend major part of their life cycle in fresh water ecosystem. Their trophic position and sensitivity to environmental degradation allow odonates to function as indicators of ecosystem quality (Westfall & May, 1999; Stewart & Samways, 1998; Clark & Samways, 1996; Samways et al., 1996; Takamura, 1996; Watson et al., 1982). Odonates are more and more recognized as indicator of a healthy aquatic ecosystem in recent years and are often termed as the bio-indicators of the aquatic ecosystem (Clark & Samways 1996). Among odonates dragonflies are considered as a potential bio control agents of mosquitoes (Sathe & Bhusnar, 2010; Mitra, 2002). Being predator during larval and adult stage plays important role in invertebrate food chain. Due to presence of fresh water in Gosabara wetland complex, the numbers of odonates species were higher.

Family: Gerridae (Water strider) from order: Hemiptera was observed during monsoon visit. Member of this family run or skate over the water surface catch the insect that fall onto the water. Most of them are fresh water dwellers and monsoon rains lessen downs the salinity thus providing chance for this water insect to sustain. Family: Lygaeidae are the seed bugs which feed on sap of seeds and are considered pest, though the number of individuals was ignorable at the study site.

Order: Coleoptera was represented by three families of which Family: Tenebrionidae was present ubiquitously they were found under dung, stones etc. Not having much decaying material or decaying wood and other sources for their food were mostly found under the dung. Family: Staphylinidae, family: Hydrophilidae and Family: Scarabaeidae were also observed. Staphylinidae (Rove beetles) are active insects and are often seen in decaying material, dung, under stone etc. decaying algae on the edge of the wetland were the best food for these beetles. Hydrophilidae; Water scavenger beetle as name suggests aquatic beetle adults are scavengers and larvae are predaceous. Survival of this insect is so easy at wetland like Gosabara Wetland which provided food for both adult and larvae. Scarabaeid beetles were observed at Gosabara Wetland complex fresh dung around the wetland of grazing cattle provided them enough facilities to survive.

Lepidopterans were represented by three families, Pieridae, Nymphalidae and Lycaenidae. Less vegetation and minimum availability of food plant is one of the reasons that not many butterflies families were sited. Nevertheless family: Pieridae was observed around the peripheries of agricultural fields around the wetland during the winter as well as during monsoon. Family Nymphalidae was represented by two very common butterflies striped tiger and plain tiger in and around the study area with availability of food plant. Lycaenidae, butterflies were plenty during monsoon season as the wetland was having enough grassy patches, some butterflies were observed enjoying mud pudding too.

Caddis fly larva cocoon belonging to order Trichoptera was found hanging to vegetation. Trichoptera are the insect which needs water during different stage of

their life cycle. Larvae fed on microorganisms and algae available in water and are food for many fresh water fishes so r they adults. Presence of diptera was due to the thrash available to devour. Family: Mucidae was Culicidae of order Diptera were hovering around the trash around the watch tower. Order: Hymenoptera with sole family: Formicidae; ants play a major role in soil turnover and also serve as food for many other groups of animals.

Total 18 species from 13 families of 6 orders were recorded during the survey. Gosabara Wetland complex is harbouring composed and typical wetland insect groups. Seasonal occurrence could be due the changes in salinity, temperature, food availability etc. Insect representative of major groups of food chain/niches were observed (Table-3.1) suggesting functional and self-sustained ecosystem of Gosabara. Less human interference/anthropological activities might help these insect communities play their role of maintenance of the equilibrium of the ecology of this protected area. Thus, the study provides overview of insects of Gosabara Wetland Complex. It also provides baseline data for upcoming researchers and will give wide scope of further investigations.

Table-3.1: Summary of the different insect families from different orders and their ecological roles.

Order	Family	General Ecological Role	
		Larva	Adult
odonata	Aeshnidae	Predator	Predator
	Libellulidae	Predator	Predator
	Coengrionidae	Predator	Predator
Hemiptera	Gerridae	Predator	Predator
	Lygaeidae	Pest	Pest
Coleoptera	Staphylinidae	Predator	predator
	Hydrophilidae	Scavenger	Scavenger
	Scarabaeidae	Root, dung and decaying material feeders	Dung feeders and decomposers
	Tenebrionidae	Omnivorous	Omnivorous
	Curculionidae	Pest	Pest
Lepioptera	Pieridae	Herbivorous	Nectorsuckers Pollinators
	Nymphailidae	Herbivorous	Nector suckers Pollinators
	Lycaenidae	Herbivorous	Nector suckers Pollinators
Tricoptera		Food for many fresh water Fishes	Food for many fresh water Fishes
Diptera	Mucidae	saprophagus	saprophagus
	Culicidae	Microorganisms available in water	vector

Plate-3.1: Major representatives of odonata reported during the study at Gosabara.

Brachythemis comtaminata Common Amberwing



Orthetrum sabina, Slender Skimmer



Crocothemis servilia, Common Scarlet



Trithemis kirby Orange-winged Dropwing



Hemianax ehippiger (Vagrant Emperor)



Pseudagrion decorum (The Elegant sprite)



Plate-3.2: Major representatives of insects reported during the study at Gosabara.

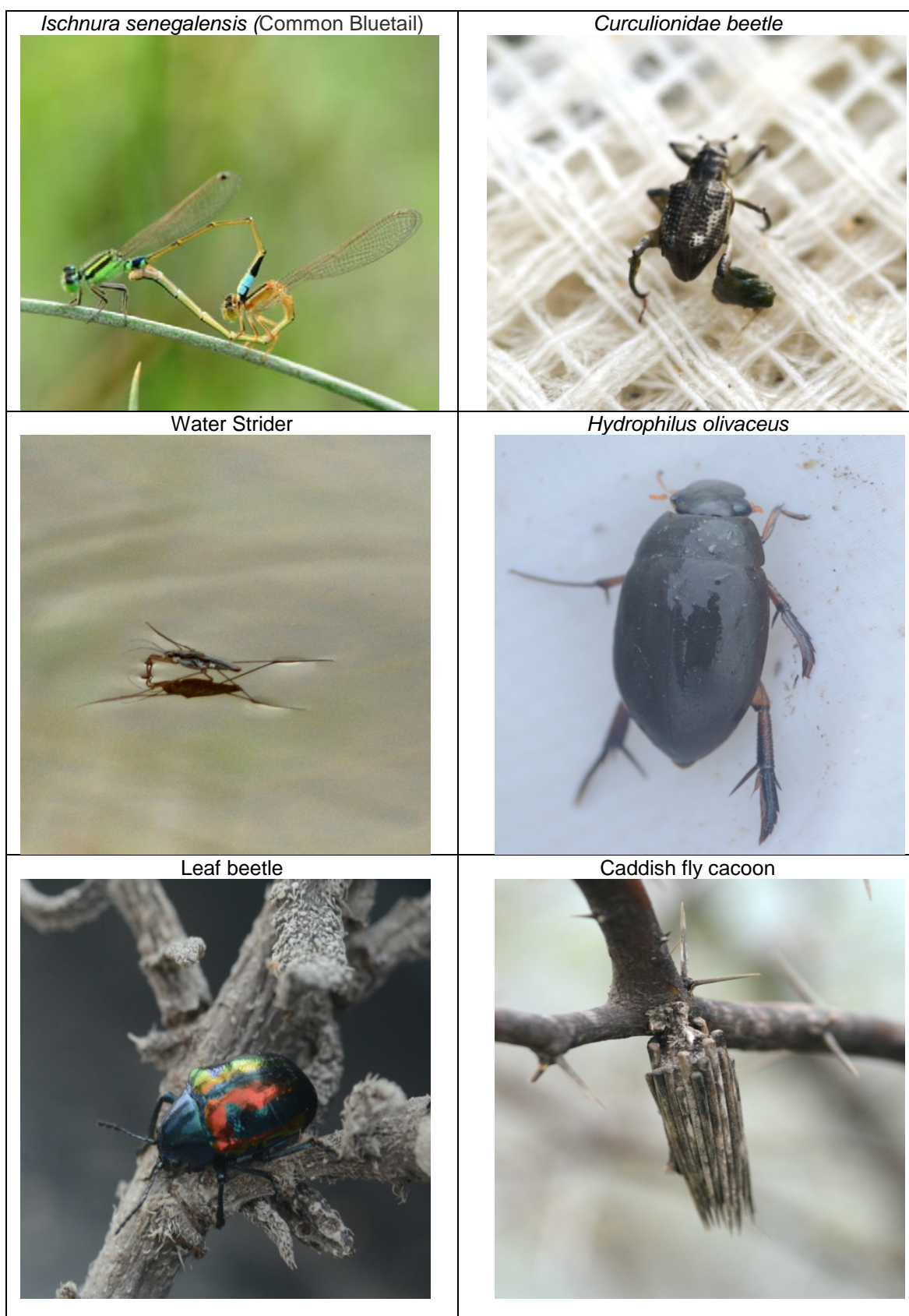








Plate-3.3: Major representatives of insects reported during the study at Gosabara wetland complex.

<p><i>Pseudozizeeria maha</i> (Pale Grass Blue)</p> 	<p><i>Danaus chrysippus</i> (Plain Tiger Butterfly)</p> 
<p><i>Colotis etrida</i> (Indian Little orange Tip)</p> 	<p><i>Euchrysops cnejus</i> (Oriental Gram Blue)</p> 
<p><i>Utetheisa lotrix</i> (Salt and Pepper Moth)</p> 	<p><i>Colotis fausta</i> (Large Salmon Arab Butterfly)</p> 

3.2. STUDY OF FISHES

3.2.1. FISH& OTHER SPECIES RICHNESS

During our surveys, we reported total 21 fish species belonging to 12 families from Gosabara Wetland complex. We recorded total 3 species belonging to 2 families of economically important crustaceans from Gosabara Wetland complex (Table-3.2). Out of the total 24 fishery fauna, 21 species belongs to class Osteichthyes (bony fish) while 3 species belongs to class Decapoda (Shrimp and Prawn).

3.2.2. FISH & OTHER SPECIES CLASSIFICATION

Among class Osteichthyes 8 species belong to the family of Cyprinidae, followed by 3 species of Family Siluridae and families such as Percidae, Ophiocephalidae, Gobiidae, Cichlidae, Channidae, Poeciliidae, Terapontidae, Leiognathidae, Notopteridae and Aplocheilidae have 1 specie seach. Among class Decapoda 2 species belongs to family Palaemonidae and 1 species belong to family Penaeidae (Figure-3.3).

Figure-3.3: Distribution of species under families and class in Gosabara wetland.

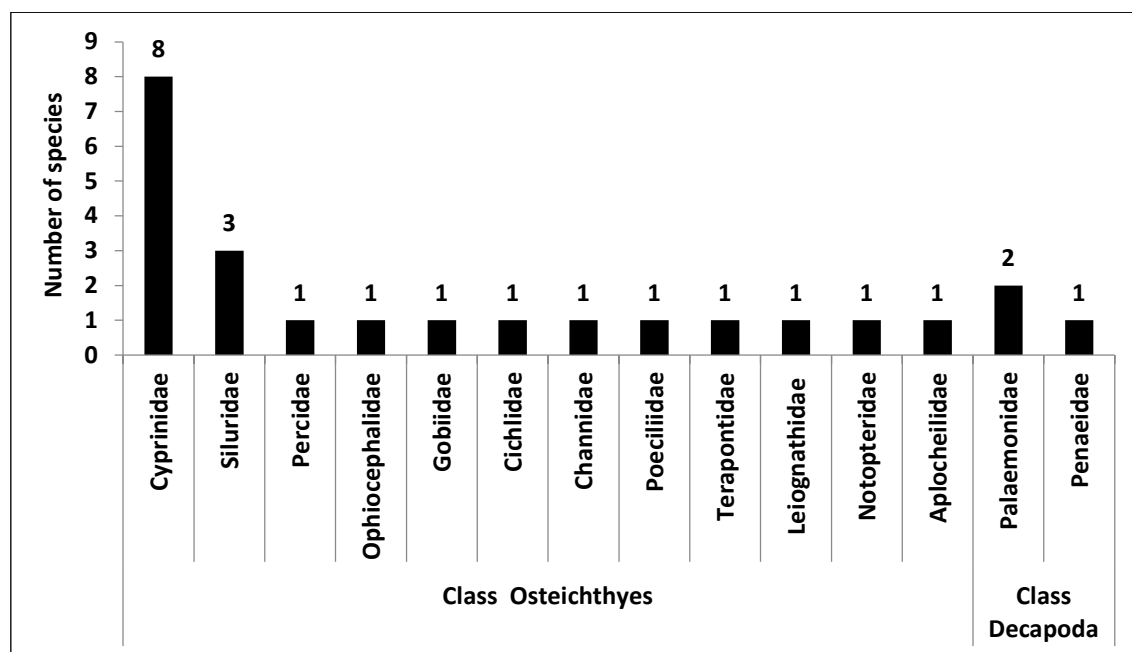


Table-3.2: Overall fish and prawn species recorded from Gosabara Wetland complex.

Family	Scientific Name	Common name	Local name	IUCN status	
FISH SPECIES	Aplocheilidae				
	1	Aplocheilus lineatus	Malabar killie	-	LC
	Channidae				
	2	Channa mircopeltes	Snakehead	Morakhi	LC
	Cichlidae				
	3	Oreochromis mossambicus	Mozambique tilapia	Tilapia	NT
	Cyprinidae				
	4	Catla Catla	Catla	Catla	LC
	5	Chela untrahi	Razorbelly minnow	Malli	LC
	6	Cirrhinus mrigala	Mrigal carp	Mrigal	LC
	7	Labeo calbasu	Orange fin Labeo	Kalidashi	LC
	8	Labeo rohita	Roho labeo	Rohu	LC
	9	Puntius sarana	Greenstripe barb	-	LC
	10	Puntius sophore	Poolbarb	Dhebri	LC
	11	Salmophasia bacaila	Large razorbelly minnow	Chela	LC
	Gobiidae				
	12	Glossogobius giuris	Tank goby	-	LC
	Leiognathidae				
	13	Aurigequula fasciata	Striped ponyfish	Chandro	LC
	Notopteridae				
	14	Notopterus notopterus	Bronze featherback	Patra	LC
Osphronemidae					
15	Trichogaster fasciata	Giant gourami	Katiyo	LC	
Percidae					
16	Parambassis ranga	Indian glassy fish	Chandro	LC	
Poeciliidae					
17	Gambusia affinis	Mosquitofish	-	LC	
Siluridae					
18	Callichrous microphthalmus	Indian butter-catfish	Jharakho	NT	
19	Mystus gulio	Long whiskers catfish	Khagi	LC	
20	Heteropneustes fossilis	Stinging catfish	Singhi	LC	
Terapontidae					
21	Terapon jarbua	Tiger perch	-	LC	
SHRIMP / PRAWNS	Palaemonidae				
	1	Nematopalaemon tenuipes	Spider prawn	-	NE
	2	Macrobrachium rosenbergii	Giant Freshwater Prawn	Jhinga	LC
	Penaeidae				
3	Metapenaeus kutchensis	Ginger Shrimp	Jhinga	NE	

3.2.3. IUCN STATUS OF FISHES

Of total recorded 20 species of fishes and associated fauna belong to the category of Least Concern, 2 species are Not Evaluated and 2 species belong to the category of Near Threatened (Table 3.2). The *Oreochromis mossambicus* has been assessed as Near Threatened species by IUCN because its population is threatened by hybridization with the rapidly spreading other species of same genus.

3.2.4. FISHING ACTIVITY IN GOSABARA WETLAND COMPLEX

Based on our interview survey of fishermen in total 4 important villages or active fishing areas we extracted certain basic information as follow. Total 4 fisherman were interviewed at Vanana creek, 7 at Gosabara and 5 at Kurly creek area. Following information was gathered from them.

Active fishing period: Active fishing period in Gosabara Wetland Complex was between Novembers to February months i.e. 5 months. During this period wetland has considerable water and the fish are grown.

Fishing Intensity: According to fishermen they are fishing for 3-5 days per week throughout the fishing season. They put in 2-5 hrs/family/day of efforts in fishing activity.

Fishing Technique used:

General practice adopted for fishing in Gosabara wetland complex is Golva fishing (Fixed net) during night (6-8 hrs. fixed net in night). They also gill net by using small boats in the wetland area. At some places they also prefer Chhogiya (cast netting) for fishing in creek areas. Vaghri community also sometime uses tyre cast netting in creeks.

Fish Catch per Day: The fishermen informed that they catch from 5-60 kg of fish per day depending on the rainy season water in the wetland and manpower involved.

Income from Fishing Activity: was estimated to be between the rate of fish that they get in the market varies from Rs. 20/kg to Rs.60/kg. The amount caught varies from 5-60 kg/day per family. Therefore, the income of a family ranges between Rs.100/day to 3000/day depending on the catch and the fish species.

Economically Important Fish Species: are Rohu, Labeo, Mrigal, Catla and Tilapia species. Rest other species are smaller in size and are not caught often. These species are larger in size and yield them considerable income.

Community involved in Fishing: There are two major communities from 4-5 surrounding villages involved into fishing activity. These are Muslims and Vaghri community. Fishing is done by Muslim community, a total of 100 families and about 400 members are altogether engaged in fishing activity makes Gosabara main fishing centre. Apart from them, members of Vaghri community from village Pipaliya are engaged in fishing.

3.2.5. IMPORTANT FISHING AREAS IN GOSABARA WETLAND

Total 3 sites have been selected for studies viz. 1) Vanana 2) Gosabara 3) Kurly Creek. The site wise detailed studies have been discussed below:

Site 1 – Vanana (21°38' 47.41" N and 69°41' 15.41" E)

Vanana is main wetland located with very rich bird diversity. Fishing activity is performed in a small freshwater channel (Width approx. 10 m). Total 9 numbers of species were recorded from this site. Two communities are involved in fishing activity; Muslim and Vaghri community. The Muslim community consists of only 1 family who is totally engaged and depend upon fishing and on the other hand the Vaghri community consists of in total 5 families who are periodically involved in fishing but during the dry seasons they are involved in other activities too to earn their livelihood. They used two types' nets 1) Fixed gill net (Golva) and 2) Cast net (Chhogiya) used for the fishing activity. Vaghri community uses tyre cast netting in middle channel. The family belonging to the Muslim community used small boats for fishing in the channel.

Water availability in this freshwater channel is 8 months from Jul to Feb while fishing activity is performing 6 months in a year from Nov to Feb (Pers. comm. with fishermen). Pipaliya village situated approximate 12 km distance from Vanana village. Fishermen (15-20 people) of Muslim community from Gosabara made temporary accommodation at this site and perform fishing activities. During August 2016 we performed fishing using mosquito net and four species were added to the list of species at this site. Three species has been captured and identified are *Parambassis ranga*, *Trichogaster fasciata*, *Nematopalaemon tenuipes* and, *Aurigequula fasciata*. All the four species are 3-5 cm in length and not useful in commercial fisheries.

Site 2 – Gosabara (21° 32' 31.8" N and 69° 43' 05.15" E)

Gosabara is main entry point of wetland and wetland near Gosabara village is containing high diversity of birds and other fauna. Fishing is done by Muslim community, a total of 100 families and about 400 members are altogether engaged in fishing activity makes Gosabara main fishing centre in Gosabara wetland complex. Apart from them members of Vaghri community from village Pipaliya are engaged in fishing. General practice is Golva fishing (Fixed net) during night (6-8 hrs. fixed net in night) and also used boat for gill netting.

They are even practising dry fishing for the following regularly available fishes.

- *Mystus vittatus*
- *Puntius sophore*
- *Salmophasia bacailus*
- *Notopterus notopterus*

During field visit we have perform fishing manually using mosquito net and collected fishes. Total seven species *Catla Catla*, *Mugil cephalus*, *Nematopalaemon tenuipes*, *Macrobrachium rosenbergii*, *Chela untrahi*, *Puntius sarana* and *Metapenaeus kutchensis* has been recorded by manual fishing at Gosabara. Total 18 number of species recorded from this site.

Site 3 – Kurly Creek (21° 38' 33.26" N and 69° 37' 57.29" E)

It is a stagnant creek with the upper side has a closed sea channel and downward side fresh water channel with check dams on both the sides. During the monsoon season, freshwater overflows and reaches the lower part in which fishing activity takes place. Only about 20 members of the 10 families of the Vaghri community are engaged in fishing. During the field visit period non-availability of water and fishes in the creek, these people going to the open sea for fishing and earning their livelihood. They prefer Chhogiya (cast netting) for the purpose of fishing. During field visits no fishing activity was observed and hence no fish have been recorded. Detailed of trend in fisheries activity has been recorded by personal communication with fishermen. Along with these 3 sites we also have performed manual fishing at Mokar village and few other sites around Gosabara wetland and reported four other species viz. *Gambusia affinis*, *Terapon jarbua*, *Glossogobius giuris* and *Aplochelius lineatus*.

3.2.6. OTHER IMPORTANT AQUATIC FAUNA

During our study of insects and fish in Gosabara Wetland Complex, while using staining method for collecting insects and fish samples, we came across 2 species of crustaceans which are not economically important but they are of higher ecological and evolutionary significance. Most crustaceans live in ocean, and are one of the important groups of the global marine ecosystem. They often occupy the tropic level between primary producers and higher-level organisms within the food web. Thus crustaceans consume organisms such as phytoplankton and also serve as food source for bigger animals like fishes and other organisms. Crustaceans also serve as a food source for humans, with crabs, lobsters, shrimp and prawns being the most popular of crustacean foods. However, freshwater crustaceans are also important for several reasons.

During August month we strained flowing water using mosquito net and recovered several specimens of crustaceans that include 1) Triops species or Tadpole Shrimp and 2) Clam Shrimp. These 2 species of crustaceans were most abundant in water during month of August. During straining of flowing waters in small channels for 5 minutes we would get about 250-300 grams of wet weight mostly consisting of these 3 species of crustaceans. Details of each of the 3 unidentified species are given up to genera (Plate-3.4).

i. Triops species

Subphylum: Crustacea
Class: Branchiopoda
Order: Notostraca
Family: Triopsidae
Genus: *Triops*
Species: *Unidentified*

ii. Clam Shrimp species

Subphylum: Crustacea
Class: Branchiopoda
Sub class: Phyllopoda
Order: Cyclotherida
Genus: *Unidentified*
Species: *Unidentified*

Plate-3.4:Triops species and Clam shrimp reported from Gosabara Wetland complex.

Tadpole Shrimp (Triops) species



Clam Shrimp species



3.2.7. CONCLUSION

Based on our study, we reported total 21 Fish species and 3 Prawn & Shrimp Species which is relatively higher than many seasonal wetlands of Gujarat. These species are naturally occurring in this wetland system and are likely to be wide spread in the catchment area and river/dam system that connects with this wetland through drainages. Gosabara wetland is located in the shallow depression at the delta of River Bhadar. Gosabara wetland is also biologically linked with Barda Wildlife Sanctuary located on the Barda hills. Gosabara wetland receives water from large area of Porbandar districts and Saurashtra region and also tidal water from Arabian Sea. Therefore, the diversity of the fishes and crustaceans is likely to be higher. In other words Gosabara wetland complex represents the fish and crustacean diversity of large part of Saurashtra region.

The wetland complex is home to two Near Threatened Fish species which requires be conserved and protected. Overall this wetland complex has preserved considerable fish and crustacean diversity which could be as a result of its high nutrient supply from the catchment areas and good water quality without pollution and sewage maintained till date.

However, over exploitation is one of the major threats that fish diversity of the wetland could be facing. Since the Gosabara wetland complex has vast catchment area and the surrounding area have agriculture fields, it is possible that residues of pesticides and fertilizers could accumulate in to this wetland and affect fishes of this wetland. The pesticide load in water shall be checked and regularly monitored for betterment of fish productivity of this wetland.

Proper management of fishery practices could help long term preservation of the fish diversity in this wetland. Conservation measures, including stopping illegal fishing, poisoning, identifying crucial breeding habitats as fish sanctuary and creating mass awareness for organic farming in catchment area could be taken up to preserve the fish fauna of this wetland complex.

Since we reported two crustacean species from this wetland complex which is of higher evolutionary and ecological significance more research shall be carried out on crustaceans and their role in this wetland.

3.2.8. SPECIES OBSERVED IN GOSABARA WETLAND

Details of some of the important fish and crustacean faunal species found in Gosabara wetland complex are given below.

i. *Labeo rohita* (Hamilton, 1822)



Species identification *Labeo rohita* (Day, 1878)
Labeo rohita (Froese and Pauly, 2017)

ii. *Labeo calbasu* (Hamilton, 1822)



Species identification *Labeo calbasu* (Day, 1878)
Labeo calbasu (Froese and Pauly, 2017)

iii. *Catla catla* (Hamilton, 1822)



Species identification	<i>Catla buchnani</i> (Day, 1878) <i>Catla catla</i> (Froese and Pauly, 2017)
Common Name	Catla
Local Name	Bawas, Tambra, Thambra

iv. *Puntius sarana* (Hamilton, 1822)



Species identification	<i>Systomus sarana</i> (Day, 1822) <i>Systomus sarana</i> (Froese and Pauly, 2017)
Common Name	Olive barb
Local Name	Dhebri

v. *Oreochromis mossambicus* (Peters, 1855)



Species	<i>Oreochromis mossambicus</i> (Peters, 1855)
identification	<i>Oreochromis mossambicus</i> (Froese and Pauly, 2017)
Common Name	Tilapia
Local Name	Bakra- South and Central Gujarat Kanksi- Saurashtra

vi. *Channa micropeltes*(Cuvier, 1831)



Species identification	<i>Channa micropeltes</i> (Cuvier, 1831) <i>Channa micropeltes</i> (Froese and Pauly, 2017)
Common Name	Tilapia
Local Name	Bakra- South and Central Gujarat Kanksi- Saurashtra

vii. *Terapon Jaruba* sp. (Forsskål, 1775)



Species	<i>Terapon jarbua</i> (Forsskål, 1775)
identification	<i>Terapon jarbua</i> (Froese and Pauly, 2017)
Common Name	Tiger perch

viii. *Glossogobuis giuris* (Hamilton, 1822)



Species	<i>Glossogobuis giuris</i> (Hamilton, 1822)
identification	<i>Glossogobuis giuris</i> (Froese and Pauly, 2017)
Common Name	Goby fish
Local Name	

ix. *Mystus gulio*(Hamilton, 1822)



Species	<i>Mystus gulio</i> (Hamilton, 1822)
identification	<i>Mystus gulio</i> (Froese and Pauly, 2017)
Common Name	Long whiskers catfish
Local name	Khaga

x. *Aurigeguula fasciata* (Lacepede, 1803)



Species	<i>Aurigeguula fasciata</i> (Lacepede, 1803)
identification	<i>Aurigeguula fasciata</i> (Froese and Pauly, 2017)
Common Name	Pony fish
Local name	Chandro

xi. *Parambassis ranga* (Hamilton, 1822)



Species	<i>Parambassis ranga</i> (Hamilton, 1822)
identification	<i>Parambassis ranga</i> (Froese and Pauly, 2017)
Common Name	Indian glassy fish
Local name	Chanda

xii. *Chela untrahi* (Day, 1869)



Species	<i>Chela untrahi</i> (Day, 1869)
identification	<i>Chela untrahi</i> (Froese and Pauly, 2017)
Common Name	Mahanadi razorbelly minnow
Local name	Chela

xiii. *Aplocheilus lineatus* (Valenciennes, 1846)



Species	<i>Aplocheilus lineatus</i> (Valenciennes, 1846)
identification	<i>Aplocheilus lineatus</i> (Froese and Pauly, 2017)
Common Name	Striped panchax
Local name	-

xiv. *Trichogaster fasciata* (Bloch & Schneider, 1801)



Species	<i>Trichogaster fasciata</i> (Bloch & Schneider, 1801)
identification	<i>Trichogaster fasciata</i> (Froese and Pauly, 2017)
Common Name	Banded gourami
Local name	Gorami

xv. *Puntius sophore* (Hamilton, 1822)



Species	<i>Puntius sophore</i> (Hamilton, 1822)
identification	<i>Puntius sophore</i> (Froese and Pauly, 2017)
Common Name	Pool barb
Local name	Dhebri

3.3. STUDY OF HERPETOFAUNA

3.3.1. AMPHIBIANS SPECIES RICHNESS

At Gosabara total 4 species of Amphibians belonging to 4 genera and 2 families i.e. Bufonidae and Ranidae were recorded (Table-3.3). All the four species were directly sighted on transects. All the four species are one of the most common food for the heronry birds in Gujarat (Vyas and Parasharya, 2016). The proliferation of these amphibian species coincides with the nesting of heronry birds. These species serve as a rich source of protein for the chicks in the absence of fishes which proliferate in the winter (Vyas and Parasharya, 2016). Due to the wider distribution, these species are not recognised for conservation concern; however the ecological significance of the species due to its utilisation as food source by the avifauna of the region cannot be neglected. Absence and low abundance of the amphibians from the agriculture land and dry open land could be due to number of reasons that should be looked into. .

Table-3.3: Amphibian species recorded from Gosabara wetland complex.

Sr. No	Common Name	Scientific Name	IUCN Status	WLPA Schedule
Family Bufonidae				
1	Common Indian Toad	<i>Duttaphrynus melanostictus</i> (Schneider, 1799)	LC	Sch-IV
2	Marbled Toad	<i>Duttaphrynus stomaticus</i> Lütken, 1864	LC	Sch-IV
Family Dicroglossidae				
3	Indian Skipping frog	<i>Euphlyctis cyanophlyctis</i> (Schneider, 1799)	LC	Sch-IV
4	Indian Bullfrog	<i>Hoplobatrachus tigerinus</i> (Daudin, 1803)	NE	Sch-IV

3.3.2. AMPHIBIANS RELATIVE ABUNDANCE

Relative abundances of amphibians were calculated using the observations made during the field (Table-3.4). Out of these four, the most abundant species was Common Indian Toad (*Duttaphrynus melanostictus*) with relative abundance of 42% followed by Marbled toad (28.6), Indian Skipping frog (14.3) and Indian Bullfrog (14.3). All the four species were recorded from the wetland habitat and dry open land in surrounding area.

Table-3.4: Relative abundance of the Amphibian species at Gosabara

No	Species	Scientific Name	Habitat			Total	% Relative Abundance
			Wet land	Dry open land	Cultivated		
1	Common Indian Toad	<i>Duttaphrynus melanostictus</i>	2	1	0	3	42.9
2	Marbled Toad	<i>Bufo stomaticus</i>	1	1	0	2	28.6
3	Indian Skipping frog	<i>Euphlyctis cyanophlyctis</i>	1	0	0	1	14.3
4	Indian Bullfrog	<i>Hoplobatrachus tigerinus</i>	1	0	0	1	14.3

3.3.3. REPTILES SPECIES RICHNESS

At Gosabara 16 species of reptiles, belonging to 14 genera and 9 families were recorded during the study (Table-3.5). Total reptilian fauna comprised of 1 species of turtle, 7 species of snakes, 3 species of lizards, 3 geckos and 2 species of skinks. The most abundant species recorded was Bengal Monitor Lizard (*Varanus bengalensis*) with relative abundance of 29% followed by Indian Garden lizard (*Calotes versicolor*) with 18% relative abundance. Out of 16 species of reptiles 10 were encountered on the sampling area i.e. transects whereas remaining 6 were recorded either from indirect evidences or from consultation with local experts. Though being a widespread species in the subcontinent the Indian Flapshell turtle, has been put under the appendix II of CITES and protected under Schedule I of the WLPA (1972), due to its heavy demand due to superstitious blind beliefs. Abundance of the reptilian fauna in the dry open land was higher compared to the moist wetland area. However, only Rat snake and Indian Cobra were recorded from the Agriculture field. *Hemidactylus robustus* was earlier described as *H. Porbandarensis* is the synonym and is thought to be introduced due to the transportation of goods from Gulf countries such as Abu Dhabi or Dubai. *H. robustus* are members of the "Arid Clade" of *Hemidactylus* (Carranza & Arnold 2006), a relatively large and diverse group of geckos mostly occurring in the Middle East and the Horn of Africa.

However species occurring in the Barda hills might be occurring in this wetland as the drainage of the hill region goes through the wetland and merges in the sea. This connecting area is vast and shall be assessed thoroughly to understand the linkage between this wetland and its catchment area in the Barda hills.

Table-3.5: Reptilian species recorded at Gosabara.

Sr. No	Common Name	Scientific Name	IUCN Status	WLPA Schedule
Family Gekkonidae				
1	Yellow-green House Gecko	<i>Hemidactylus flaviviridis</i> Ruppell, 1835	LC	NA
2	Brooke's Gecko	<i>Hemidactylus brookii</i> Gray, 1845	NE	NA
3	Porbandar Gecko	<i>Hemidactylus robustus</i> Heyden, 1827	NE	NA
Family Varanidae				
4	Bengal Monitor lizard	<i>Varanus bengalensis</i> (Daudin, 1802)	LC	I
Family Agamidae				
5	Garden lizard	<i>Calotes versicolor</i> (Daudin, 1802)	NE	NA
Family Lacertidae				
6	Indian fringe finger lizard	<i>Acanthodactylus cantoris</i> Günther, 1864	LC	NA
Family Elapidae				
7	Indian Cobra	<i>Naja naja</i> (Linnaeus, 1758)	NE	II
Family Colubridae				
8	Indian Rat snake	<i>Ptyas mucosa</i> (Linnaeus, 1758)	NE	II
9	Common Wolf snake	<i>Lycodon aulicus</i> (Linnaeus, 1758)	LC	IV
10	Buff striped keelback	<i>Amphiesma stolatum</i> (Linnaeus, 1758)	NE	IV
11	Checkered keelback	<i>Xenochrophis piscator</i> (Schneider, 1799)	LC	II
12	Indian Trinket	<i>Coelognathus helena</i> (Daudin, 1803)	NE	IV
Family Viperidae				
13	Sawscaled viper	<i>Echis carinatus</i> (Schneider, 1801)	NE	IV
Family Trionychidae				
14	Indian flapshell	<i>Lissemys punctata</i> (Lacépède, 1788)	LC	I
Family Scincidae				
15	Bronze skink	<i>Eutropis macularia</i> (Blyth, 1853)	NE	NA
16	Spotted supple skink	<i>Lygosoma punctata</i> Gmelin 1799	NE	NA

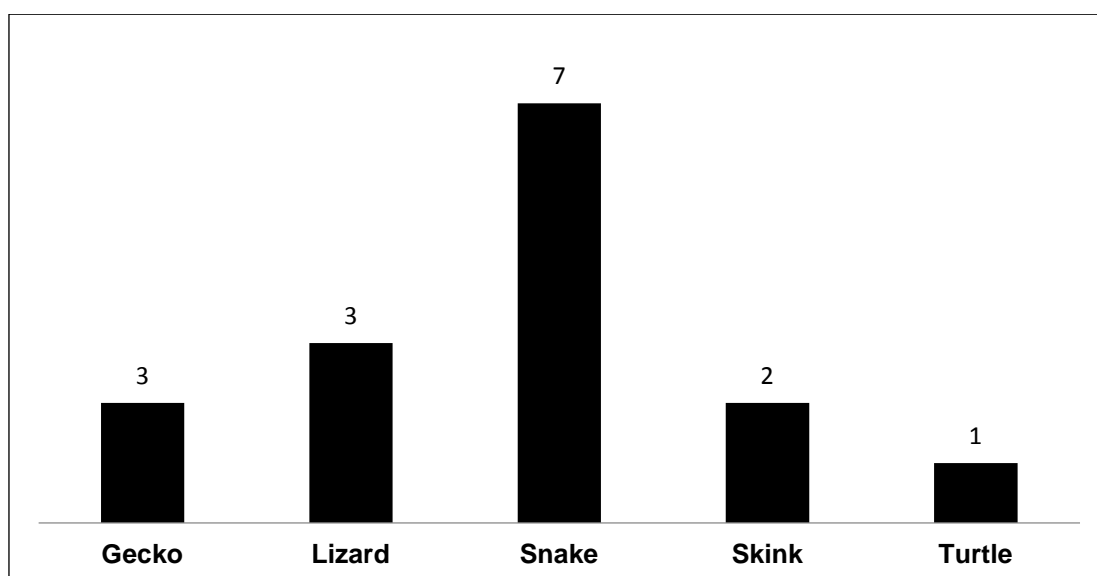
3.3.4. REPTILE RELATIVE ABUNDANCE

Relative abundances of amphibians were calculated (Michael, 1986) using the observations made during the field visits (Table-3.6). Out of 15 species of reptiles, 9 species were sighted directly during field sampling for which relative abundance is calculated. Bengal Monitor Lizard is one of the most encountered and had highest relative abundance (30%) followed by Garden Lizard 19%, Chequered Killback with 11% rest all were below 8% (Table-3.8). The higher abundance of Monitor lizard could probably because of the amount of food avail in the form of small fauna. Sightings of reptiles among habitats were almost same with minor differences (Table-3.8).

Table-3.6: Relative abundance of Reptile species at Gosabara Wetland Complex.

No	Species	Habitat			Total encounter	% Relative Abundance
		Wetland	Dry open land	Cultivated		
1	Bengal Monitor lizard	5	2	1	8	29.6
2	Garden lizard	0	2	3	5	18.5
3	Checkered keelback	3	0	0	3	11.1
4	Yellow-green House Gecko	0	1	1	2	7.4
5	Brooke's Gecko	0	1	1	2	7.4
6	Indian flapshell	2	0	0	2	7.4
7	Bronze skink	0	1	1	2	7.4
8	Spotted supple skink	0	1	1	2	7.4
9	Indian fringe finger lizard	0	1	0	1	3.7

Figure-3.4: Species in each reptilian representative group at Gosabara.



3.4. STUDY OF BIRDS

Birds are an important component of biotic community of any ecosystem. They respond quickly to changing in habitat thus, birds are good bioindicators of habitat quality, productivity, and stability of any ecosystem (Pertti Koskimies, 1998; Roché et al 2010). The information on diversity and their abundance helps in conservation and management of threatened and endangered bird species. The alteration in habitats may cause changes in avian abundance and diversity. About 1300 species of bird i.e. About 13 % of the world's bird (Grimmett et al. 1998) are recorded from Indian subcontinent. India ranks third in having a large number of threatened and rare species (Dandapat et al. 2010).

3.4.1. STUDY OF WATERBIRDS

3.4.1.1. WATERBIRD POPULATION ESTIMATE

The population of waterbird estimates was carried out on 28-29 January 2016. During water bird estimation we reported a total of 108 waterbirds and water dependent bird species in Gosabara wetland complex (Table-3.7 & Table-3.8). Waterbird population estimated in 5 different zones of Gosabara wetland complex was highest so far i.e. 3,79,382 birds in (Table-3.9). Total 100 species of waterbirds and wetland dependent or wetland associated birds were observed during this estimation. There were some groups of gulls, terns, and waders etc. which were also estimated.

Table-3.7: Zone wise number and percentage of estimated waterbirds in Gosabara wetland complex during 28-29 January 2016.

Zone	Karli	Dharampur	Vanana	Odadar	Gosabara	Total
Number	18134	1991	91467	108581	159209	3,79,382
Percent	4.8	0.5	24.1	28.6	42	100

Table-3.8: Details of zone wise waterbirds population estimates in Gosabara wetland complex.

NO	COMMON NAME	CENSUS ZONES					
		Karli	Dharampur	Vanana	Odadar	Gosabara	TOTAL
GREBES							
1	Little Grebe	31	22	1		150	204
2	Great Crested Grebe	2					2
PELICANS							
3	Great White	200	5	6	500	1470	2181
4	Dalmatian	15	3	1	120	83	222
CORMORANTS & DARTER							
5	Great	0		5	5	20	30
6	Little	1603	3	32	320	2100	4058
7	Indian	100			240	60	400
8	Darter	5	1		2	3	11
HERONS, EGRETS & BITTERNS							
9	Grey Heron	9	2	18	10	70	109
10	Purple Heron	11	2	16	6	90	125
11	Great White Egret	1303	7	19	150	835	2314
12	Median Egret	50	3	11	103	218	385
13	Little Egret	100	6	30	36	283	455
14	Cattle Egret	0			200	1262	1462
15	Western Reef Egret	8				33	41
16	Indian Pond Heron	28	3	45	500	4506	5082
17	Night Heron	2					2
STORKS							
18	Painted Stork	70		3	830	740	1643
19	Wooly-necked Stork			7	4	2	13
20	Asian Openbill	2					2
IBISES & SPOONBILL							
21	Red-naped Ibis	4		1	5	15	25
22	Eurasian Spoonbill	10	2	49	950	2400	3411
23	Black-headed Ibis	5		1		1370	1376
24	Glossy Ibis	20	3	9	205	648	885
FLAMINGOS							
25	Greater	26		161	4450	5000	9637
26	Lesser	100		165	6045	16100	22410
GEESE & DUCKS							
27	Greylag Goose					105	105
28	Brahminy Shelduck	5			8	2	15
29	Cotton Teal		3			175	178
30	Northern Pintail	500		15014	2090	3000	20604
31	Common Teal	120		4559	3650	6600	14929
32	Spot-billed Duck	12	52	31	200	4830	5125

NO	COMMON NAME	CENSUS ZONES					
		Karli	Dharampur	Vanana	Odadar	Gosabara	TOTAL
33	Garganey	10	25	5070	250	30	5385
34	Common Pochard	4	12	4500	500	1220	6236
35	Comb Duck		2	19		250	271
36	Eurasian Wigeon	50	18	6049	1500	1500	9117
37	Gadwall	10	8	2150	2290	2312	6770
38	Northern Shoveler	2778	2	6102	4580	2800	16262
	Unidentified ducks					15000	15000
CRANES							
39	Common Crane	2		7500	5000	8410	20912
40	Demoiselle Crane	5025	1020	35000	21000	8500	70545
RAILS, GALLINULES & COOT							
41	Baillon's Crake	1					1
42	Brown Crake	1					1
43	Great Bittern					1	1
44	Purple Swampphen	120	10	2310	2300	2700	7440
45	White-breasted Waterhen	4	6	7	11	13	41
46	Common Moorhen	4	3	5	6	41	59
47	Common Coot	750	263	540	1480	9500	12533
JACANAS							
48	Pheasant-tailed		7	21		240	268
SHOREBIRDS - WADERS							
49	Avocet			5	200	70	275
50	Black-winged Stilt	150	114	170	340	1300	2074
51	Yellow-wattled Lapwing	2	3	6	0	7	18
52	White-tailed Lapwing					6	6
53	Red-wattled Lapwing	20	12	45	60	710	847
54	Pacific Golden Plover					2	2
55	Little Ringed Plover				30	10	40
56	Kentish Plover				25	200	225
57	Greater Sand Plover				31	10	41
58	Lesser Sand Plover				2000	120	2120
59	Black-tailed Godwit	90	24	819	6000	4412	11345
60	Whimbrel				18		18
61	Marsh Sandpiper	1		6	55	230	292
62	Wood Sandpiper	7	1	4		650	662
63	Common Redshank	1	0		3029	1000	4030
64	Common Greenshank	1	24	8	17	71	121
65	Green Sandpiper	5	2	10	19	200	236
66	Common Sandpiper	14	28	18	33	362	455
67	Common Snipe	16	23	8	19	56	122
68	Little Stint	210		523	9580	500	10813
69	Temminck's Stint	4	4	1	52	10	71

NO	COMMON NAME	CENSUS ZONES					
		Karli	Dharampur	Vanana	Odadar	Gosabara	TOTAL
70	Dunlin			8	50		58
71	Ruff	100	3	45	6250	4000	10398
	Unidentified shorebirds				11000	5000	16000
GULLS, TERNS & SKIMMER							
72	Pallas's Gull	30		1			31
73	Black-headed Gull	500	11			350	861
74	(Heuglin's) Gull			2		2	4
75	Brown-headed Gull	3004				220	3224
76	Slender-billed Gull				4	3	7
	Unidentified gulls				10000	10000	20000
77	Whiskered Tern	513		14	12	100	639
78	Gull-billed Tern	13		2		210	225
79	Caspian Tern	4			6	25	35
80	Sandwich Tern					4	4
81	River Tern	100	1	19	100	1270	1490
82	Lesser Crested Tern					50	50
	Unidentified terns					1000	1000
WETLAND DEPENDENT BIRDS							
HAWKS, EAGLES, OSPREY & FALCONS							
83	Western Marsh-Harrier	4		5	12	20	41
84	Peregrine Falcon		1			2	3
85	Brahminy Kite	1		1		1	3
86	Greater Spotted Eagle			3	2	0	5
87	Osprey	1		2	2	0	5
KINGFISHERS							
88	Small Blue Kingfisher	4	6	3	4	17	34
89	White-breasted	13	11	12	20	28	84
90	Lesser Pied Kingfisher	2		1	2	13	18
SWALLOWS							
91	Common Swallow					20000	20000
92	Wire-tailed Swallow	100	4	100		250	454
93	Red-rumped Swallow	100	190	136	52	1800	2278
WAGTAILS & PIPITS							
94	White Wagtail	2				40	42
95	White-browed Wagtail	2	3	3		15	23
96	Yellow Wagtail	9	10	12	4	32	67
97	Citrine Wagtail	11	23	15	7	136	192
98	Grey Wagtail						0
ADDITIONAL SPECIES OF WATERBIRDS							
99	Small Pratincole			3			3
100	Indian Courser					8	8
	TOTAL	18134	1991	91467	108581	159209	379382

3.4.1.2. COMPARISON OF POPULATION ESTIMATES WITH PREVIOUS ESTIMATES

The present waterbird estimates is highest so far in comparison with previous two estimates made in Gosabara by different agencies (Table-3.9). The difference in the population estimates are likely to be due to condition and the availability of water in the wetland. The difference due to manpower used and the coverage of wetland during census could also be one of the reasons. However, that would not cause major difference.

Table-3.9: Comparison of waterbird estimates carried out in Gosabara wetland complex between years 2014 to 2016.

Year	Population	Conducted by	Remarks
2014	1,18,975	Dr. Indra Gadhvi (Gadhvi 2014)	Coverage unknown
2015	94,204	Mokarsagar Wetland Conservation Committee (www.mokarsagar.org/)	Only 50% coverage
2016 ¹	3,79,382	GIZ- CMPA Project - Forest Department	More than 80% coverage
2017	53,237	Mokarsagar Wetland Conservation Committee (www.mokarsagar.org/)	Average 85% coverage

3.4.1.3. WATERBIRD SPECIFIC RAMSAR CRITERIA

Under the Ramsar Convention Criteria, wetlands should be selected for the Ramsar List on account of their international significance in terms of the biodiversity and uniqueness of their ecology, botany, zoology, limnology or hydrology. In addition, the Criteria indicate that in the first instance, wetlands of international importance to waterbirds at any season should be included on the Ramsar List. One of the specific criteria based on waterbirds is their 1% geographic population (Li et al 2009). Another Ramsar Convention criterion is that a wetland can be considered internationally important if it regularly supports 20,000 or more waterbirds.

In case of Gosabara wetland complex, it fits in both the waterbird specific criteria as it regularly supports much more than 20,000 birds. And the waterbird population estimate suggests that the Gosabara wetland complex supports 1% populations of 32 species (Table-3.10). This number is probably the highest by far in any wetlands of Gujarat.

¹The field survey of the current study was conducted during the year 2016

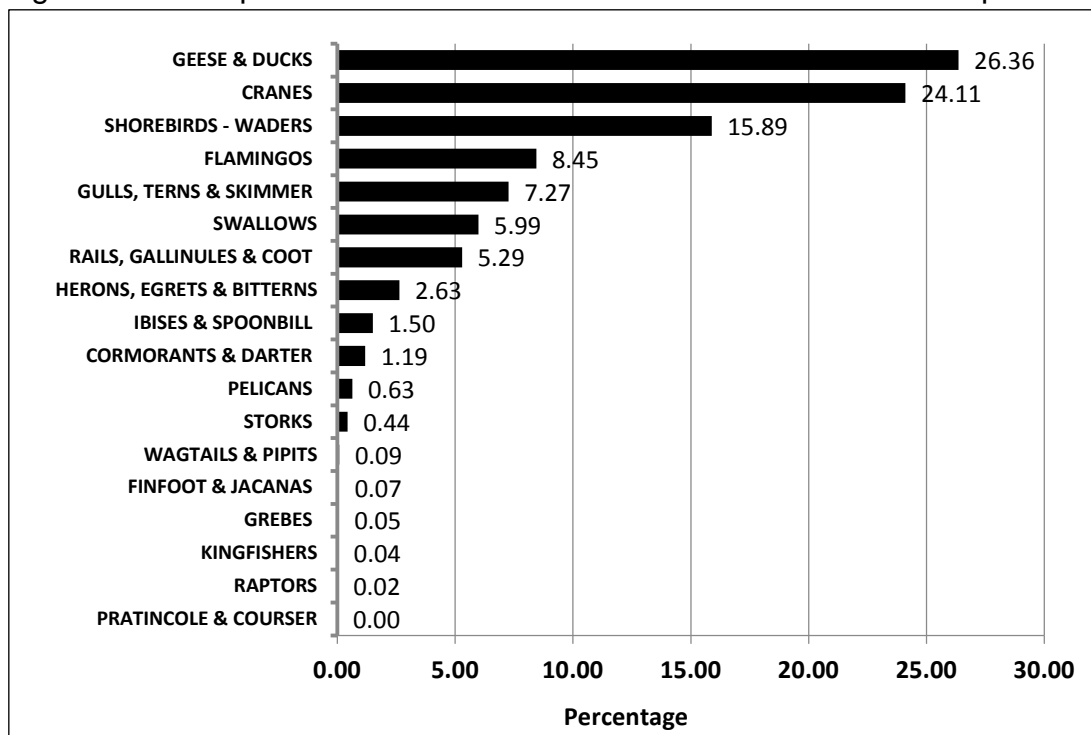
Table-3.10: One percent (1%) population of different waterbird species observed during January -2016 in Gosabara wetland complex.

No.	Name of Bird	Scientific Name of Bird	Number observed	1% Population Reference (Li et al. 2009)
1	Northern Shoveller	<i>Anas clypeata</i>	16262	7500
2	Common Teal	<i>Anas crecca</i>	14929	4000
3	Lesser Flamingo	<i>Phoenicopterus minor</i>	22410	3900
4	Garganey	<i>Anas querquedula</i>	5385	3500
5	Common Pochard	<i>Aythya ferina</i>	6236	3500
6	Gadwall	<i>Anas strepera</i>	6770	3000
7	Eurasian Wigeon	<i>Anas penelope</i>	9117	2500
8	Northern Pintail	<i>Anas acuta</i>	20604	2500
9	Little Cormorant	<i>Phalacrocorax niger</i>	4058	2500
10	Little Stint	<i>Calidris minuta</i>	10813	2500
11	Greater Flamingo	<i>Phoenicopterus ruber</i>	9637	2400
12	Black-winged Stilt	<i>Himantopus himantopus</i>	2074	1750
13	Black-tailed Godwit	<i>Limosa limosa</i>	11345	1500
14	Brown-headed Gull	<i>Larus brunnicephalus</i>	3224	1500
15	Lesser Sand Plover	<i>Charadrius mongolus</i>	2120	1300
16	Spot-billed Duck	<i>Anas poecilorhyncha</i>	5125	1000
17	Eurasian Spoonbill	<i>Platalea leucorodia</i>	3411	1000
18	Great White Egret	<i>Casmerodius albus</i>	2314	1000
19	Demoiselle Crane	<i>Grus virgo</i>	70545	1000
20	Common Redshank	<i>Tringa totanus</i>	4030	1000
21	Ruff	<i>Philomachus pugnax</i>	10398	1000
22	River Tern	<i>Sterna aurantia</i>	1490	750
23	Common Crane	<i>Grus grus</i>	20912	700
24	Red-wattled Lapwing	<i>Vanellus indicus</i>	847	500
25	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	400	300
26	Comb Duck	<i>Sarkidiornis melanotos</i>	271	250
27	Painted Stork	<i>Mycteria leucocephala</i>	1643	250
28	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	1376	250
29	Glossy Ibis	<i>Plegadis falcinellus</i>	885	250
30	Purple Swamphen	<i>Porphyrio porphyrio</i>	7440	250
31	Great White Pelican	<i>Pelecanus onocrotalus</i>	2181	230
32	Dalmatian Pelican	<i>Pelecanus crispus</i>	222	75

3.4.1.4. POPULATIONS OF BIRD GROUPS

The estimate made during January 2016 suggests that Ducks, Cranes & Flamingos makes most of the waterbird populations in Gosabara wetland complex (Figure-3.5).

Figure-3.5: Group wise count of waterbirds in Gosabara wetland complex.



3.4.1.5. WATERBIRD SPECIES RICHNESS

During the course of entire study, total 112 waterbirds and water dependent bird species were sighted in Gosabara wetland complex (Table-3.11).

- Of these 112 species reported, 60 species are migratory and 52 are resident species (Table-3.11).
- Of 112 species reported, 98 species are considered as Least Concerned as per IUCN category, where as 4 species are considered as Vulnerable and 10 species are found to be Near Threatened (Table-3.11).
- There was only Schedule-I waterbird species as per Wildlife Protection Act 1972. It was only Eurasian Spoonbill (Table-3.11).
- This site is also used by 2 species of migratory cranes for roosting i.e. Common Crane and Demoiselle Crane (Map-3.1).The site has great potential to be declared as Ramsar site or wetlands of national and international importance as it meets several of the criteria for declaration of Ramsar site.

Map-3.1: Major Crane roosting sites in Gosabara wetland complex.



Table- 3.11: Checklist and details of Waterbirds population estimates and sightings in Gosabara wetland complex.

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	CONSERVATION STATUS	
					IUCN STATUS	WPA Schedule
1	Asian Openbill	<i>Anastomus oscitans</i>	R	CARN	LC	IV
2	Baillon's Crake	<i>Zapornia pusilla</i>	M	INS	LC	IV
3	Bar-tailed Godwit	<i>Limosa lapponica</i>	M	CARN	NT	IV
4	Black-crowned Night Heron	<i>Nycticorax nycticorax</i>	R	CARN	LC	IV
5	Black-headed Gull	<i>Larus ridibundus</i>	M	PISC	LC	IV
6	Black-headed Ibis	<i>Threskiornis melanocephalus</i>	R	CARN	NT	IV
7	Black-tailed Godwit	<i>Limosa limosa</i>	M	CARN	NT	IV
8	Black-winged Stilt	<i>Himantopus himantopus</i>	R	CARN	LC	IV
9	Broad-billed Sandpiper	<i>Limicola falcinellus</i>	M	CARN	LC	IV
10	Brown Crake	<i>Zapornia akool</i>	R	OMNI	LC	IV
11	Brown-headed Gull	<i>Larus brunnicephalus</i>	M	PISC	LC	IV
12	Caspian Tern	<i>Hydroprogne caspia</i>	M	PISC	LC	IV
13	Cattle Egret	<i>Bubulcus ibis</i>	R	CARN	LC	IV
14	Citrine Wagtail	<i>Motacilla citreola</i>	M	INS	LC	IV
15	Comb Duck	<i>Sarkidiornis melanotos</i>	R	OMNI	LC	IV
16	Common Coot	<i>Fulica atra</i>	R	HERB	LC	IV
17	Common Crane	<i>Grus grus</i>	M	OMNI	LC	IV
18	Common Greenshank	<i>Tringa nebularia</i>	M	CARN	LC	IV
19	Common Kingfisher	<i>Alcedo atthis</i>	R	CARN	LC	IV
20	Common Moorhen	<i>Gallinula chloropus</i>	R	OMNI	LC	IV
21	Common Pochard	<i>Aythya ferina</i>	P	OMNI	VU	IV
22	Common Redshank	<i>Tringa totanus</i>	M	CARN	LC	IV
23	Common Sandpiper	<i>Actitis hypoleucos</i>	M	CARN	LC	IV
24	Common Snipe	<i>Gallinago gallinago</i>	M	CARN	LC	IV
25	Common Teal	<i>Anas crecca</i>	M	PISC	LC	IV
26	Cotton Pigmy- Goose	<i>Nettapus coromandelianus</i>	R	PISC	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	CONSERVATION STATUS	
					IUCN STATUS	WPA Schedule
27	Curlew Sandpiper	<i>Calidris ferruginea</i>	M	CARN	LC	IV
28	Dalmatian Pelican	<i>Pelecanus crispus</i>	M	PISC	VU	IV
29	Demoiselle Crane	<i>Grus virgo</i>	M	OMNI	LC	IV
30	Dunlin	<i>Calidris alpina</i>	M	CARN	LC	IV
31	Eurasian Curlew	<i>Numenius arquata</i>	M	CARN	NT	IV
32	Eurasian Oystercatcher	<i>Haematopus ostralegus</i>	M	CARN	NT	IV
33	Eurasian Spoonbill	<i>Platalea leucorodia</i>	R	CARN	LC	I
34	Eurasian Thick-knee	<i>Burhinus oedicephalus</i>	R	CARN	LC	IV
35	Eurasian Wigeon	<i>Mareca penelope</i>	M	PISC	LC	IV
36	Gadwall	<i>Mareca strepera</i>	M	PISC	LC	IV
37	Garganey	<i>Spatula querquedula</i>	M	PISC	LC	IV
38	Glossy Ibis	<i>Plegadis falcinellus</i>	R	CARN	LC	IV
39	Great Bittern	<i>Botaurus stellaris</i>	M	PISC	LC	IV
40	Great Cormorant	<i>Phalacrocorax carbo</i>	R	PISC	LC	IV
41	Great Crested Grebe	<i>Podiceps cristatus</i>	R	PISC	LC	IV
42	Great Thick-knee	<i>Esacus recurvirostris</i>	R	CARN	NT	IV
43	Great White Egret	<i>Casmerodius albus</i>	R	CARN	LC	IV
44	Great White Pelican	<i>Pelecanus onocrotalus</i>	M	PISC	LC	IV
45	Greater Flamingo	<i>Phoenicopterus ruber</i>	R	OMNI	LC	IV
46	Greater Sand Plover	<i>Charadrius leschenaultii</i>	M	CARN	LC	IV
47	Green Sandpiper	<i>Tringa ochropus</i>	M	CARN	LC	IV
48	Grey Heron	<i>Ardea cinerea</i>	R	CARN	LC	IV
49	Grey Plover	<i>Pluvialis squatarola</i>	M	CARN	LC	IV
50	Grey Wagtail	<i>Motacilla cinerea</i>	M	INS	LC	IV
51	Greylag Goose	<i>Anser anser</i>	M	HERB	LC	IV
52	Gull-billed Tern	<i>Sterna nilotica</i>	M	PISC	LC	IV
53	Heuglin's Gull	<i>Larus heuglini</i>	M	PISC	LC	IV
54	Indian Black Ibis	<i>Pseudibis papillosa</i>	R	CARN	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	CONSERVATION STATUS	
					IUCN STATUS	WPA Schedule
55	Indian Clamorous Reed-warbler	<i>Acrocephalus stentoreus</i>	R	INS	LC	IV
56	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	R	PISC	LC	IV
57	Indian Pond-heron	<i>Ardeola grayii</i>	R	CARN	LC	IV
58	Intermediate Egret	<i>Mesophoyx intermedia</i>	R	CARN	LC	IV
59	Jack Snipe	<i>Lymnocyptes minimus</i>	M	CARN	LC	IV
60	Kentish Plover	<i>Charadrius alexandrinus</i>	M	CARN	LC	IV
61	Lesser Crested Tern	<i>Sterna bengalensis</i>	M	PISC	LC	IV
62	Lesser Flamingo	<i>Phoenicopterus minor</i>	R	OMNI	NT	IV
63	Lesser Sand Plover	<i>Charadrius mongolus</i>	M	CARN	LC	IV
64	Lesser Whistling-duck	<i>Dendrocygna javanica</i>	R	OMNI	LC	IV
65	Little Cormorant	<i>Phalacrocorax niger</i>	R	PISC	LC	IV
66	Little Egret	<i>Egretta garzetta</i>	R	CARN	LC	IV
67	Little Grebe	<i>Tachybaptus ruficollis</i>	R	PISC	LC	IV
68	Little Ringed Plover	<i>Charadrius dubius</i>	M	CARN	LC	IV
69	Little Stint	<i>Calidris minuta</i>	M	CARN	LC	IV
70	Little Tern	<i>Sterna albifrons</i>	M	PISC	LC	IV
71	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M	CARN	LC	IV
72	Northern Pintail	<i>Anas acuta</i>	M	OMNI	LC	IV
73	Northern Shoveller	<i>Anas clypeata</i>	M	OMNI	LC	IV
74	Oriental Darter	<i>Anhinga melanogaster</i>	R	PISC	NT	IV
75	Oriental Pratincole	<i>Glareola maldivarum</i>	R	CARN	LC	IV
76	Pacific Golden Plover	<i>Pluvialis fulva</i>	M	CARN	LC	IV
77	Painted Snipe	<i>Rostratula benghalensis</i>	R	CARN	LC	IV
78	Painted Stork	<i>Mycteria leucocephala</i>	R	CARN	NT	IV
79	Pallas's Gull	<i>Ichthyaelus ichthyaelus</i>	M	PISC	LC	IV
80	Pheasant-tailed Jacana	<i>Hydrophasianus chirurgus</i>	R	OMNI	LC	IV
81	Pied Avocet	<i>Recurvirostra avosetta</i>	M	CARN	LC	IV
82	Pied Kingfisher	<i>Ceryle rudis</i>	R	CARN	LC	IV

No	Name of Bird	Scientific Name of Bird	Migratory status	Feeding Guild	CONSERVATION STATUS	
					IUCN STATUS	WPA Schedule
83	Pied Kingfisher	<i>Ceryle rudis</i>	R	PISC	LC	IV
84	Purple Heron	<i>Ardea purpurea</i>	R	CARN	LC	IV
85	Purple Swampphen	<i>Porphyrio porphyrio</i>	R	OMNI	LC	IV
86	Red-wattled Lapwing	<i>Vanellus indicus</i>	R	CARN	LC	IV
87	River Tern	<i>Sterna aurantia</i>	R	PISC	NT	IV
88	Ruddy Shelduck	<i>Tadorna ferruginea</i>	M	OMNI	LC	IV
89	Ruddy Turnstone	<i>Arenaria interpres</i>	M	CARN	LC	IV
90	Ruff (M) and Reeve (F)	<i>Philomachus pugnax</i>	M	OMNI	LC	IV
91	Sanderling	<i>Calidris alba</i>	M	CARN	LC	IV
92	Sandwich Tern	<i>Thalasseus sandvicensis</i>	R	PISC	LC	IV
93	Sarus Crane	<i>Antigone antigone</i>	R	OMNI	VU	IV
94	Slender-billed Gull	<i>Larus genei</i>	M	PISC	LC	IV
95	Small Pratincole	<i>Glareola lactea</i>	R	INS	LC	IV
96	Spot-billed Duck	<i>Anas poecilorhyncha</i>	R	OMNI	LC	IV
97	Spotted Redshank	<i>Tringa erythropus</i>	M	CARN	LC	IV
98	Temminck's Stint	<i>Calidris temminckii</i>	M	CARN	LC	IV
99	Western Reef-heron	<i>Egretta gularis</i>	R	CARN	LC	IV
100	Whimbrel	<i>Numenius phaeopus</i>	M	CARN	LC	IV
101	Whiskered Tern	<i>Chlidonias hybrida</i>	M	PISC	LC	IV
102	White Wagtail	<i>Motacilla cinerea</i>	M	INS	LC	IV
103	White-breasted Waterhen	<i>Amaurornis phoenicurus</i>	R	OMNI	LC	IV
104	White-tailed Lapwing	<i>Vanellus leucurus</i>	M	INS	LC	IV
105	White-throated Kingfisher	<i>Halcyon smyrnensis</i>	R	CARN	LC	IV
106	Wire-tailed Swallow	<i>Hirundo smithii</i>	R	INS	LC	IV
107	Wood Sandpiper	<i>Tringa glareola</i>	M	CARN	LC	IV
108	Woolly-necked Stork	<i>Ciconia episcopus</i>	R	CARN	VU	IV
109	Yellow Bittern	<i>Ixobrychus sinensis</i>	R	CARN	LC	IV
110	Yellow Wagtail	<i>Motacilla flava</i>	M	OMNI	LC	IV
111	Yellow-legged Gull	<i>Larus cachinnans</i>	M	PISC	LC	IV
112	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	R	CARN	LC	IV

R=Resident, M=Migratory; C=Carnivore, P=Piscivore, O=Omnivore, I=Insectivore; LC=Least Concerned, NT=Near Threatened, VU=Vulnerable; IV= Schedule-IV, I=Schedule-I as per Wildlife Protection Act.

3.4.1.6. FEEDING GUILD DISTRIBUTION

The feeding guild of the waterbird showed that there were more carnivorous species i.e. 49.1%, Piscivorous 25.0%, Omnivorous 17.0%, Insectivorous were 7.1% and Herbivorous were 1.8%.

The higher number of carnivore species, followed by piscivorous and omnivorous is typical composition of large and highly productive wetland eco-system.

From the aforesaid results it is evident that Gosabara wetland complex is hosting large populations of waterbirds and that too birds of higher trophic levels (secondary consumers). It reflects the fact that this wetland is highly productive eco-system. These results also suggest that this wetland is an important feeding ground for large number of carnivore, piscivore, insectivore birds.

3.4.2. STUDY OF TERRESTRIAL BIRDS

3.4.2.1. TOTAL SPECIES RICHNESS

During terrestrial bird surveys using various methods such as extensive search method, random point sampling, random encounters, as well as fixed spot sampling methods in Gosabara wetland complex we found total 118 terrestrial bird species (Table-3.13). The number of species recorded during winter were 114 where as only 80 species were reported during summer season. Lesser number of species reported during summer could be due to higher temperature, high wind speed and lack of food and water in Gosabara wetland complex.

3.4.2.2. OVERALL BIRD DENSITY

The overall density of terrestrial birds in Gosabara wetland complex during winter was estimated to be $40.3.1 \pm 3.8$ (SE) birds per ha. and 28.9 ± 3.2 (SE) in summer season. The overall terrestrial bird density differed significantly between two seasons due to drying of water in Summer seasons from Gosabara wetland complex. Apart from this the agriculture field also dries up during summer season and above all the migratory species are absent from this landscape during summer.

3.4.2.3. SPECIES SPECIFIC DENSITY

Total 78 bird species were recorded during the sampling efforts in winter and summer seasons. Density of each of the species recorded is given in Table-3.12. During winter density of Rosy starling was as high as 6.7 birds/ha. rest of the birds i.e. House crow, Red-vented Bulbul, House sparrow etc. remained at lower densities (Table-3.12). During summer the density of local resident bird species were very low which remained below 1bird/ha. in entire study area sampled (Table-3.12). This could be due to variety of reasons such as differential habitat and food requirements of different bird species.

3.4.2.4. SPECIES DIVERSITY

The overall terrestrial bird species diversity index using Shannon Diversity Index (Shannon and Wiener, 1949) was estimated to be 3.5 in winter ($n=41$) and 4.12 ($n=41$) in summer season in and around Gosabara wetland complex. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. The Shannon index increases as both the richness and the evenness of the community increase. However, the higher value of Shannon Diversity Index clearly suggests that terrestrial bird diversity is very high in Gosabara wetland complex during both winter and summer seasons. The higher diversity of terrestrial birds in wetland eco-systems is naturally justified as the majority of the area is wetland which supports variety of life forms. The Simpson Index (Simpson 1949) for winter was 0.048 and 0.014 for summer suggesting no major differences in the diversity in two seasons. The species richness i.e. Margalef's Richness Index (Margalef, 1958) differed between two seasons as it was 7.3 in winter and 11.4 in summer season.

Table-3.12: Species specific density of terrestrial birds recorded in winter and summer season and around Gosabara wetland complex.

No	Species	Winter		Summer	
		AVG	SE	AVG	SE
1	Ashy Prinia	0.43	0.07	0.35	0.17
2	Ashy-crowned Finch-lark	0.95	0.15	0.43	0.22
3	Asian Koel			0.52	0.23
4	Bank Myna			0.60	0.24
5	Baya Weaver Weaver			0.26	0.19
6	Bay-backed Shrike			0.35	0.17
7	Black Drongo	0.86	0.13	0.69	0.25
8	Black Kite			0.95	0.33
9	Black Redstart	0.43	0.07		
10	Black-winged Kite	0.43	0.07	0.43	0.18
11	Bluethroat			0.26	0.15
12	Brahminy Kite			0.52	0.23
13	Brahminy Starling			0.43	0.22
14	Chestnut-bellied Sandgrouse			0.60	0.21
15	Common Babbler	1.21	0.19	0.52	0.20
16	Common Hoopoe	0.60	0.09	0.52	0.23
17	Common Iora			0.43	0.18
18	Common Kingfisher	0.43	0.07	0.09	0.09
19	Common Myna	1.55	0.24	0.43	0.18
20	Common Stonechat	0.43	0.07		
21	Common Tailorbird			0.35	0.21
22	Common Woodshrike			0.26	0.19
23	Coppersmith Barbet			0.78	0.29
24	Crested Lark	0.95	0.15	0.17	0.12
25	Eurasian Collared-dove	0.43	0.07	0.78	0.26
26	Greater Coucal	0.78	0.12	0.26	0.19
27	Greater Short-toed Lark	0.52	0.08		
28	Grey Francolin	1.04	0.16	0.43	0.22
29	Grey Wagtail	0.60	0.09		
30	Grey-breasted Prinia			0.43	0.18
31	House Crow	1.99	0.31	0.60	0.27
32	House Sparrow	1.55	0.24	0.43	0.22
33	Indian Clamorous Reed-warbler	0.43	0.07	0.35	0.17
34	Indian Courser			0.52	0.26

No	Species	Winter		Summer	
		AVG	SE	AVG	SE
35	Indian Peafowl	0.35	0.05	0.43	0.22
36	Indian Roller	0.60	0.09	0.35	0.17
37	Indian Silverbill			0.35	0.17
38	Isabelline Shrike	0.26	0.04		
39	Jungle Babbler	1.55	0.24	0.35	0.21
40	Jungle Prinia			0.52	0.20
41	Large Grey Babbler	1.64	0.26	0.69	0.22
42	Laughing Dove	0.95	0.15	0.78	0.26
43	Little Green Bee-eater	1.21	0.19	0.60	0.24
44	Long-tailed Shrike	0.35	0.05	0.69	0.28
45	Montagu's Harrier	0.52	0.08		
46	Oriental Honey-buzzard			0.35	0.17
47	Oriental Magpie-Robin	0.43	0.07	0.35	0.21
48	Oriental White-eye			0.26	0.15
49	Paddyfield Pipit	0.35	0.05	0.60	0.27
50	Pallid Harrier	0.35	0.05		
51	Peregrine Falcon			0.60	0.30
52	Pied Bushchat			0.60	0.27
53	Plain Prinia	0.35	0.05	0.43	0.18
54	Purple Sunbird	0.78	0.12	0.43	0.18
55	Purple-rumped Sunbird			0.43	0.18
56	Red Collared-dove	0.35	0.05	0.35	0.17
57	Red-rumped Swallow			0.35	0.21
58	Red-vented Bulbul	1.38	0.22	0.17	0.12
59	Red-wattled Lapwing	1.99	0.31	0.17	0.12
60	Rock Pigeon	1.04	0.16	0.17	0.12
61	Rose-ringed Parakeet			0.35	0.17
62	Rosy Starling	6.73	1.05		
63	Rufous Treepie	0.60	0.09	0.43	0.18
64	Rufous-tailed Lark			0.52	0.26
65	Sand Lark			0.09	0.09
66	Sand-martin			0.26	0.19
67	Shikra	0.17	0.03	0.60	0.27
68	Singing Bushlark			0.43	0.18
69	Southern Grey Shrike			0.26	0.19
70	Western Yellow Wagtail	0.26	0.04		

No	Species	Winter		Summer	
		AVG	SE	AVG	SE
71	White Wagtail	0.35	0.05		
72	White-browed Wagtail	0.26	0.04		
73	White-eared Bulbul			0.26	0.19
74	White-throated Kingfisher	0.43	0.07	0.35	0.17
75	Wire-tailed Swallow			0.43	0.18
76	Yellow-throated Sparrow	0.78	0.12	0.52	0.20
77	Yellow-wattled Lapwing	0.52	0.08	0.26	0.19
78	Zitting Cisticola			0.35	0.17

Table-3.13: Checklist and details of terrestrial birds in Gosabara wetland complex.

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
1	Ashy Prinia	<i>Prinia socialis</i>	INSC	R	LC	IV	1	1
2	Ashy-crowned Sparrow Lark	<i>Eremopterix grisea</i>	GRAN	R	LC	IV	1	1
3	Asian Koel	<i>Eudynamys scolopacea</i>	OMNI	R	LC	IV		1
4	Bank Myna	<i>Acridotheres ginginianus</i>	OMNI	R	LC	IV	1	1
5	Barn Swallow	<i>Hirundo rustica</i>	INSC	M	LC	IV	1	
6	Barred Buttonquail	<i>Turnix suscitator</i>	GRAN	R	LC	IV	1	
7	Bay backed shrike	<i>Lanius vittatus</i>	INSC	R	LC	IV	1	1
8	Baya Weaver	<i>Ploceus philippinus</i>	INSC	R	LC	IV	1	1
9	Black Drongo	<i>Dicrurus macrocercus</i>	INSC	R	LC	IV	1	1
10	Black Kite	<i>Milvus migrans</i>	CARN	R	LC	I	1	1
11	Black Redstart	<i>Phoenicurus ochruros</i>	INSC	M	LC	IV	1	
12	Black-headed Bunting	<i>Emberiza melanocephala</i>	GRAN	M	LC	IV	1	
13	Black-rumped Flameback	<i>Dinopium benghalense</i>	INSC	R	LC	IV	1	1
14	Black-shouldered Kite	<i>Elanus caeruleus</i>	CARN	R	LC	I	1	
15	Blue-cheeked Bee-eater	<i>Merops persicus</i>	INSC	R	LC	IV	1	1
16	Bluethroat	<i>Cyanecula svecica</i>	INSC	M	LC	IV	1	
17	Brahmini kite	<i>Haliastur indus</i>	CARN	R	LC	I	1	1
18	Brahminy Starling	<i>Sturnus pagodarum</i>	OMNI	R	LC	IV	1	1
19	Chestnut-bellied Sandgrouse	<i>Pterocles exustus</i>	GRAN	R	LC	IV		1
20	Chestnut-shouldered petronia	<i>Gymnoris xanthocollis</i>	OMNI	R	LC	IV	1	1
21	Citrine Wagtail	<i>Motacilla citreola</i>	INSC	M	LC	IV	1	
22	Clamorous Reed Warbler	<i>Acrocephalus stentoreus</i>	INSC	R	LC	IV	1	1
23	Common Babbler	<i>Argya caudata</i>	INSC	R	LC	IV	1	1
24	Common Chiffchaff	<i>Phylloscopus collybita</i>	INSC	M	LC	IV	1	
25	Common Hoopoe	<i>Upupa epops</i>	INSC	R	LC	IV	1	1
26	Common Iora	<i>Aegithina tiphia</i>	INSC	R	LC	IV	1	1
27	Common Kestrel	<i>Falco tinnunculus</i>	CARN	M	LC	IV	1	
28	Common Myna	<i>Acridotheres tristis</i>	OMNI	R	LC	IV	1	1

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
29	Common Stonechat	<i>Saxicola torquatus</i>	INSC	M	LC	IV	1	
30	Common Tailorbird	<i>Orthotomus sutorius</i>	INSC	R	LC	IV	1	1
31	Common Woodshrike	<i>Tephrodornis pondicerianus</i>	INSC	R	LC	IV	1	1
32	Coppersmith Barbet	<i>Megalaima haemacephala</i>	FRUG	R	LC	IV		1
33	Crested Lark	<i>Galerida cristata</i>	GRAN	R	LC	IV	1	1
34	Desert Wheatear	<i>Oenanthe deserti</i>	INSC	M	LC	IV	1	
35	Dusky Crag Martin	<i>Hirundo concolor</i>	INSC	R	LC	IV	1	1
36	Egyptian Vulture	<i>Neophron percnopterus</i>	SCAV	R	EN	I		1
37	Eurasian Collared Dove	<i>Streptopelia decaocto</i>	GRAN	R	LC	IV	1	1
38	Eurasian Golden Oriole	<i>Oriolus oriolus</i>	INSC	R	LC	IV	1	1
39	European Roller	<i>Coracias garrulus</i>	INSC	M	LC	IV	1	
40	Graceful Prinia	<i>Prinia gracilis</i>	INSC	R	LC	IV	1	
41	Greater Coucal	<i>Centropus sinensis</i>	OMNI	R	LC	IV	1	1
42	Greater Short-toed Lark	<i>Calandrella brachydactyla</i>	GRAN	M	LC	IV	1	
43	Green Bee-eater	<i>Merops orientalis</i>	INSC	R	LC	IV	1	1
44	Grey francolin	<i>Francolinus pondicerianus</i>	GRAN	R	LC	IV	1	1
45	Grey Wagtail	<i>Motacilla cinerea</i>	INSC	M	LC	IV	1	
46	Grey-breasted Prinia	<i>Prinia hodgsonii</i>	INSC	R	LC	IV	1	1
47	House Crow	<i>Corvus splendens</i>	OMNI	R	LC	IV	1	1
48	House Sparrow	<i>Passer domesticus</i>	GRAN	R	LC	IV	1	1
49	House Swift	<i>Apus affinis</i>	INSC	R	LC	IV	1	1
50	Indian Bushlark	<i>Mirafr erythroptera</i>	GRAN	R	LC	IV		1
51	Indian Courser	<i>Cursorius coromandelicus</i>	OMNI	R	LC	IV	1	1
52	Indian Nightjar	<i>Caprimulgus asiaticus</i>	INSC	R	LC	IV		1
53	Indian Peafowl	<i>Pavo cristatus</i>	OMNI	R	LC	I	1	1
54	Indian Robin	<i>Saxicoloides fulicata</i>	INSC	R	LC	IV	1	1
55	Indian Roller	<i>Coracias benghalensis</i>	INSC	R	LC	IV	1	1
56	Indian Silverbill	<i>Lonchura malabarica</i>	GRAN	R	LC	IV	1	1
57	Indian Spotted Eagle	<i>Clanga hastata</i>	CARN	R	VU	I	1	
58	Isabelline Wheatear	<i>Oenanthe isabellina</i>	INSC	M	LC	IV	1	
59	Isabelline Shrike	<i>Lanius isabellinus</i>	INSC	M	LC	IV	1	

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
60	Jungle Babbler	<i>Turdoides striata</i>	OMNI	R	LC	IV	1	1
61	Jungle Prinia	<i>Prinia sylvatica</i>	INSC	R	LC	IV	1	
62	Large Grey Babbler	<i>Argya malcolmi</i>	OMNI	R	LC	IV	1	1
63	Large-billed Crow	<i>Corvus macrorhynchos</i>	OMNI	R	LC	IV		1
64	Laughing Dove	<i>Streptopelia senegalensis</i>	GRAN	R	LC	IV	1	1
65	Lesser Whitethroat	<i>Sylvia curruca</i>	INSC	M	LC	IV	1	
66	Long-tailed Shrike	<i>Lanius schach</i>	INSC	R	LC	IV	1	1
67	Marshall's iora	<i>Aegithina nigrolutea</i>	INSC	R	LC	IV	1	1
68	Montagu's Harrier	<i>Circus pygargus</i>	CARN	M	LC	I	1	
69	Oriental Honey-buzzard	<i>Pernis ptilorhyncus</i>	CARN	R	LC	I	1	1
70	Oriental Magpie Robin	<i>Copsychus saularis</i>	INSC	R	LC	IV	1	1
71	Oriental Skylark	<i>Alauda gulgula</i>	GRAN	R	LC	IV	1	1
72	Oriental White-eye	<i>Zosterops palpebrosus</i>	INSC	R	LC	IV	1	1
73	Orphean Warbler	<i>Sylvia hortensis</i>	INSC	M	LC	IV	1	
74	Osprey	<i>Pandion haliaetus</i>	PISC	R	LC	I	1	
75	Paddyfield Pipit	<i>Anthus rufulus</i>	INSC	R	LC	IV	1	1
76	Paddyfield Warbler	<i>Acrocephalus agricola</i>	INSC	M	LC	IV	1	
77	Pallid Harrier	<i>Circus macrourus</i>	CARN	M	NT	I	1	
78	Peregrine Falcon	<i>Falco peregrinus</i>	CARN	R	LC	I	1	
79	Pied Bushchat	<i>Saxicola caprata</i>	INSC	R	LC	IV	1	
80	Pied Crested Cuckoo	<i>Clamator jacobinus</i>	INSC	M	LC	IV		1
81	Plain Prinia	<i>Prinia inornata</i>	INSC	R	LC	IV	1	1
82	Purple Sunbird	<i>Cinnyris asiaticus</i>	NECT	R	LC	IV	1	1
83	Purple-rumped Sunbird	<i>Nectarinia zeylonica</i>	NECT	R	LC	IV	1	1
84	Rain Quail	<i>Coturnix coromandelica</i>	OMNI	R	LC	IV		1
85	Red Collared Dove	<i>Streptopelia tranquebarica</i>	GRAN	R	LC	IV	1	1
86	Red-rumped Swallow	<i>Hirundo daurica</i>	INSC	R	LC	IV	1	
87	Red-throated Flycatcher	<i>Ficedula parva</i>	INSC	M	LC	IV	1	
88	Red-vented Bulbul	<i>Pycnonotus cafer</i>	OMNI	R	LC	IV	1	1
89	Red-wattled Lapwing	<i>Vanellus indicus</i>	INSC	R	LC	IV	1	1
90	Rock Pigeon	<i>Columba livia</i>	GRAN	R	LC	IV	1	1

No.	Name of Bird	Scientific Name of Bird	Feeding Guild	Migratory status	IUCN STATUS	WPA Schedule	Season	
							Winter	Summer
91	Rose-ringed Parakeet	<i>Psittacula krameri</i>	FRUG	R	LC	IV	1	1
92	Rosy Starling	<i>Sturnus roseus</i>	INSC	M	LC	IV	1	
93	Rufous Treepie	<i>Dendrocitta vagabunda</i>	OMNI	R	LC	IV	1	1
94	Rufous-tailed Lark	<i>Ammomanes phoenicurus</i>	GRAN	R	LC	IV	1	1
95	Sand Lark	<i>Calandrella raytal</i>	OMNI	R	LC	IV	1	1
96	Sand Martin	<i>Riparia riparia</i>	INSC	R	LC	IV	1	
97	Shikra	<i>Accipiter badius</i>	CARN	R	LC	IV	1	1
98	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	CARN	R	LC	I	1	1
99	Singing Bushlark	<i>Mirafra cantillans</i>	OMNI	R	LC	IV	1	1
100	Small Minivet	<i>Pericrocotus cinnamomeus</i>	INSC	R	LC	IV		1
101	Southern Grey Shrike	<i>Lanius meridionalis</i>	INSC	R	LC	IV	1	1
102	Spotted Owlet	<i>Athene brama</i>	CARN	R	LC	IV	1	1
103	Steppe Eagle	<i>Aquila nipalensis</i>	CARN	M	LC	I	1	
104	Sykes's Lark	<i>Galerida deva</i>	OMNI	R	LC	IV	1	1
105	Sykes's Nightjar	<i>Caprimulgus mahrattensis</i>	INSC	R	LC	IV	1	1
106	Tawny Eagle	<i>Aquila rapax</i>	CARN	R	LC	IV		1
107	Tawny Pipit	<i>Anthus campestris</i>	INSC	M	LC	IV	1	
108	Variable Wheatear	<i>Oenanthe picata</i>	INSC	M	LC	IV	1	
109	Western Marsh Harrier	<i>Circus aeruginosus</i>	CARN	M	LC	I	1	
110	White eared bulbul	<i>Pycnonotus leucotis</i>	FRUG	R	LC	IV	1	1
111	White Wagtail	<i>Motacilla alba</i>	INSC	M	LC	IV	1	
112	White-eyed Buzzard	<i>Butastur teesa</i>	CARN	R	LC	I		1
113	White-throated Fantail	<i>Rhipidura albicollis</i>	INSC	R	LC	IV		1
114	Wire-tailed Swallow	<i>Hirundo smithii</i>	INSC	R	LC	IV	1	1
115	Yellow Wagtail	<i>Motacilla flava</i>	INSC	R	LC	IV	1	
116	Yellow-crowned Woodpecker	<i>Dendrocopos mahrattensis</i>	INSC	R	LC	IV		1
117	Yellow-wattled Lapwing	<i>Vanellus malarbaricus</i>	INSC	R	LC	IV	1	1
118	Zitting Cisticola	<i>Cisticola juncidis</i>	INSC	R	LC	IV	1	

R=Resident, M=Migratory; CARN=Carnivore, PISC=Piscivore, OMNI=Omnivore, INSC=Insectivore; LC=Least Concerned, NT=Near Threatened, VU=Vulnerable; IV= Schedule-IV, I= Schedule-I as per Wildlife Protection Act

3.4.2.5. FEEDING GUILDS OF TERRESTRIAL BIRDS

A feeding guild can be defined as “a group of species that exploits the same class of environmental resources in the same way (Root 1967). Avian feeding guilds have been suggested as a suitable indicator to monitor all components and interactions of an ecosystem (Ghazoul and Hellier 2000). Guild categorization among birds emphasizes upon functional component of community in an ecosystem (Wilson 1999). The wetland is used by a diverse number of bird species for foraging, nesting and roosting due to their heterogeneity of microhabitats and available rich food resources. Terrestrial bird community was categorized into following feeding guilds.

Grainivorous: Feeds on grains

Frugivorous: Feeds on fruits

Insectivorous: Feeds on insects

Herbivorous: Feeding on young shoots, roots, leaves and sprouts of vegetation.

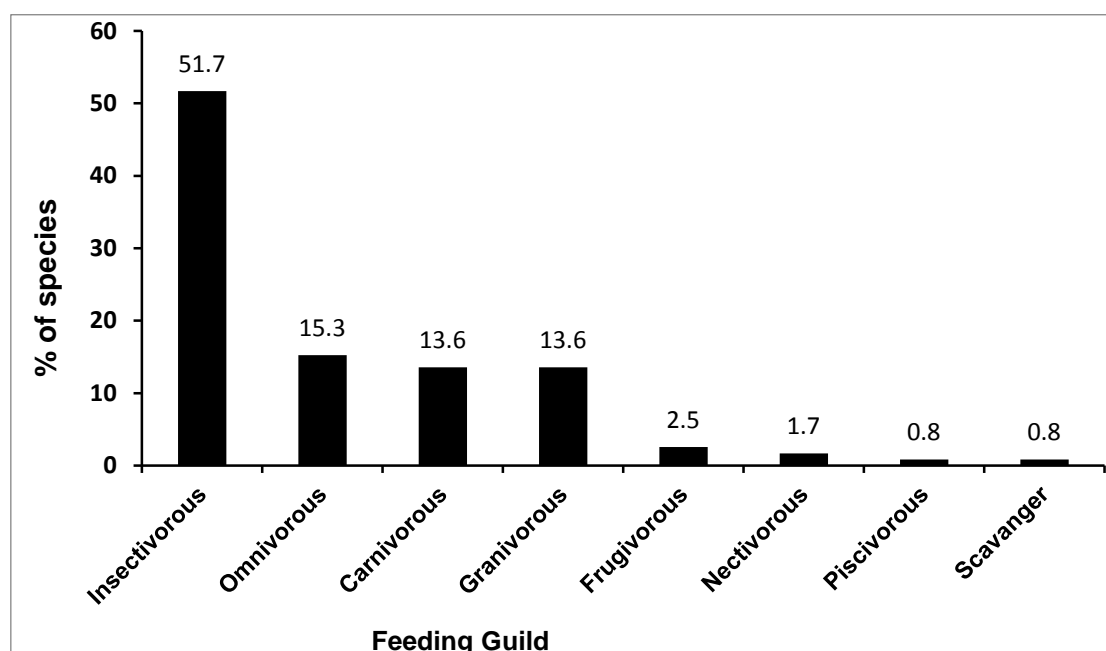
Omnivorous: Feeding on all types of food including vegetable matter, fruit, insects and other animal matter.

Carnivorous: Feeds animal matter such as fish, amphibians, reptiles, birds and small mammals.

Nectivorous: Feeds on nector of flowers

Gosabara is a large and very productive seasonal wetland and it provides feeding grounds for a diverse range of resident and migratory birds. Our survey results suggests that majority of the terrestrial birds recorded in Gosabara wetland complex to insectivorous birds 51.7%, followed by omnivorous birds 15.3%, carnivorous birds 13.6%, granivorous birds 13.6%, frugivorous 2.6%, insectivorous 1.7% and piscivorous 0.8% and scavenger birds were 0.8% (Figure-3.6). This composition of birds is typical of highly productive wetland ecosystems.

Figure-3.6: Feeding guild wise distribution of terrestrial birds in Gosabara wetland complex.



3.5. STUDY OF MAMMALS

3.5.1. SPECIES RICHNESS OF MAMMALS

Mammal surveys carried out in and around in Gosabara wetland complex in December-2015 and during January-May 2016. During our field surveys, we recorded total 14 species from 11 families of mammals through direct sightings and indirect evidences in Gosabara wetland complex (Table-3.14).

Table-3.14: Mammals species recorded in Gosabara wetland complex through various methods.

Sr. No	Common Name	Scientific Name	IUCN status	WPA (1972)	Observed using method*
Family: Felidae					
1	Jungle Cat	<i>Felis chaus</i>	LC	Sch-II	1
Family: Canidae					
2	Indian Wolf	<i>Canis lupus pallipes</i>	EN	Sch-I	5
3	Indian Fox	<i>Vulpes bengalensis</i>	LC	Sch-II	1,2
4	Jackal	<i>Canis aureus</i>	LC	Sch-II	1,3
Family: Herpestidae					
5	Common Mongoose	<i>Herpestes edwardsii</i>	LC	Sch-IV	1,2
Family: Bovidae					
6	Blue Bull	<i>Boselaphus tragocamelus</i>	LC	Sch-III	1,4,5,6
Family: Suidae					
7	Indian Wild Pig	<i>Sus scrofa</i>	LC	Sch-III	1,4,5,6
Family: Leporidae					
8	Indian Hare	<i>Lepus nigricollis</i>	LC	Sch-IV	1,2
Family: Sciuridae					
9	Fivestriped Squirrel	<i>Funambulus pennantii</i>	LC	Sch-IV	1
Family: Muridae					
10	Indian Gerbil	<i>Tatera indica</i>	LC	Sch-IV	2
Family: Pteropodidae					
11	Indian Flying fox	<i>Pteropus giganteus</i>			1
Family: Vespertilionidae					
12	Indian Pygmy Pispistrelle	<i>Pipistrellus mimus</i>	LC	Sch-IV	1
Family: Rhinopomatidae					
13	Lesser mouse-tailed bat	<i>Rhinopoma hardwickii</i>	LC	Sch-IV	1
14	Greater mouse-tailed bat	<i>Rhinopoma microphyllum</i>	LC	Sch-IV	1
* Methods 1=Random Observations, 2= Specific Habitat Search, 3 =Howling Surveys, 4= Block Counts, 5= Interview Surveys, 6= Camera trap surveys					

3.5.2. POPULATION ESTIMATES OF NILGAI

It was feasible to get total counts of some of the large and conspicuous species such as Wild Pigs and Nilgai in open and small landscape of Gosabara wetland complex. We therefore, divided Gosabara wetland complex in to three major zones/blocks which were generally to avoid waterscape during winter and include dry wetland in summer.

These total counts were made by different teams walking and scanning entire zone area and using binoculars and spotting scopes between 4:30 to 6:30 PM in winter and summer seasons. This timing was finalized based on our observations on their relative numbers in Gosabara wetland complex area during morning, afternoon and evening hours. We found that during winter and summer seasons, these animals are found to take refuge in Gosabara wetland complex. During day time, their numbers are highest during evening hours as they are found to rest in open areas in bigger herds. It was observed that due to presence of crops in the surrounding agriculture fields, they are chased away by farmers during day time. However, during night hours they venture again into agriculture fields.

During block counts for Nilgai population carried out in Gosabara wetland complex we reported total 119 individuals in winter and 127 in summer in three zones (Table-3.15). There was not much difference in population of Nilgai estimated in winter and in summer.

Table-3.15: Population of Nilgai Gosabara wetland complex.

Season	Zone-1 Mokar	Zone-2 Ratanpar Odadar	Zone-3 Vanana-Dharampur	Total
Winter	45	28	46	119
Summer	43	32	52	127

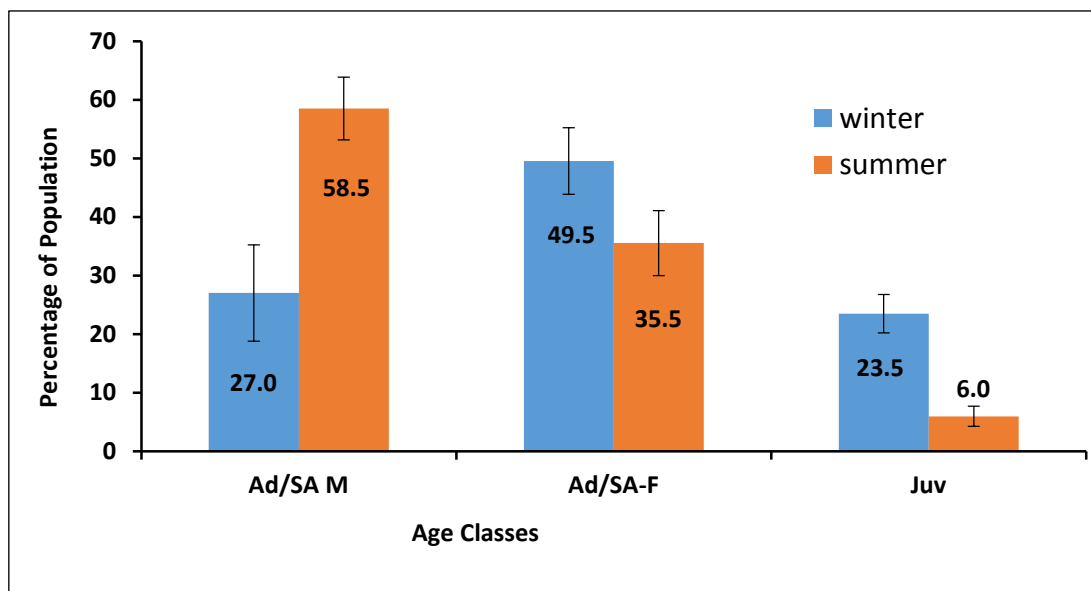
3.5.3. POPULATION STRUCTURE OF NILGAI IN GOSABARA

The population structure of Nilgai in Gosabara wetland complex suggests that their breeding was post-monsoon and foaling was in winter season as the number of juveniles in the population was higher during winter season (Figure-3.7).

3.5.4. AVERAGE GROUP SIZE OF NILGAI IN GOSABARA WETLAND

The average group size of Nilgai was 7.0 ± 0.5 (SE) where as it reduced to 5.2 ± 0.5 in summer in Gosabara wetland complex.

Figure-3.7: Population structure of Nilgai in Gosabara wetland complex during winter and summer seasons.



3.5.5. POPULATION OF WILD PIG

The block counts carried out for Wild Pig population in Gosabara wetland complex reported total 161 individuals in winter and 136 individuals in summer in three zones (Table-3.16). The zones used for Nilgai population count are the same zones used for wild pig population count.

Table-3.16: Population of Wild Pigs in Gosabara wetland complex in December 2015.

Season	Zone-1 Mokar	Zone-2 Ratanpar- Odadar	Zone-3 Vanana- Dharmpur	Total
Winter	44	85	32	119
Summer	37	74	25	136

3.5.6. PEOPLE'S PERSPECTIVE

In order to improve checklist of mammals, we also interviewed several local nature photographers, local naturalists and the farmers and cattle herders from the surrounding area (n=26) of the Gosabara wetland complex. According to farmers of the surrounding area of Gosabara wetland complex, Nilgai and Wild Pigs are major species that raid their crops of groundnut and sorghum etc. During winter farmers have to invest more time and efforts to protect their crop particularly in the immediate surroundings of the Gosabara wetland complex. Gosabara wetland complex provides much needed shelter and water to the population of Nilgai and Wild Pigs. Dense *Prosopis juliflora* thickets along with freshwater availability within such areas provide undisturbed refuge to these two species. In other words, these two species have their source populations within Gosabara wetland complex area which constantly disperses in to surrounding areas of the region.

Current Threats to the Wetland

4. ASSESSMENT OF CURRENT THREATS TO ECOLOGICAL ELEMENTS

4.1. POPULATION OF FERAL DOGS

During our visits, we observed dogs chasing large flocks of waterbirds, disturbing and killing them. This is a regular event in many parts of wetland where large flocks of cranes and flamingo are roosting during night hours. It is therefore, recommended that authorities shall take up measures to control dog population around wetland (Plate-6.1).

Plate-6.1: Dog chasing a flock of cranes in Gosabara wetland complex.



4.2. POWERLINE COLLISION OF BIRDS

During winter season, large flocks of waterbird particularly flamingo and crane which are known to fly during dark hours flies into powerlines around wetland. This often happens near Gosabara village where flamingo regularly move between coast and wetland (Plate-6.2).

4.3. FISHING PRACTICES

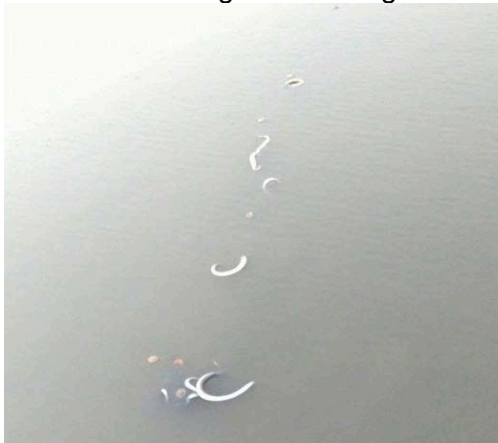
During survey we observed that fishermen uses fixed gillnet. The net is laid during night hours and kept overnight in water. We observed in one instance that 7 water snakes and several birds got entangled and died into such net (Plate-6.3). While preying on entangled birds some mammalian species such as Jungle cat etc. also are trapped in nets. Therefore, there shall be regulations on using such nets where maximum bird concentration is observed during nights.

Plate-6.2: Powerline collision of Lesser Flamingo near Gosabara wetland complex.



Plate-6.3: Fishing net proving death-trap for animals in Gosabara wetland complex.

Snakes entangled in fishing net



Bird entangled in



Fishing net entangled in Jungle cat's neck



4.4. POACHING OF WATERBIRDS:

Poaching of waterbirds from Gosabara wetland complex is often reported in local news papers. Large flocks of cranes ducks, coots etc. attracts poachers to hunt them. This activity in and around Gosabara wetland complex shall be curbed by keeping close watch on major roosting and congregation sites of waterbirds in wetland during every winter season.

Economically Important Species

5. TASK-5. IDENTIFY ECONOMICALLY IMPORTANT SPECIES

The task given refers to 'identification of economically important faunal species at Gosabara wetland complex based on current and potential use of these species by the local community'.

The economically important species includes mostly freshwater and marine fish species that are reported in section 3.2. Most of the fish and crustaceans are edible and are used as food. Some of the species are used to make fish food and some are also used in aquarium trade in market. Total 24 fresh water and marine fishery species reported from Gosabara wetland complex and surrounding marine creek areas are economically important which are listed below Table-5.1.

Table-5.1: Economically important species of Gosabara wetland complex.

No	Scientific Name	Common name	Local name
1	<i>Aplocheilichthys lineatus</i>	Malabar killie	-
2	<i>Channa micropeltes</i>	Snakehead	Morakhi
3	<i>Oreochromis mossambicus</i>	Mozambique tilapia	Tilapia
4	<i>Catla Catla</i>	Catla	Catla
5	<i>Chela untrahi</i>	Razorbelly minnow	Malli
6	<i>Cirrhinus mrigala</i>	Mrigal carp	Mrigal
7	<i>Labeo calbasu</i>	Orange fin Labeo	Kalidashi
8	<i>Labeo rohita</i>	Roho labeo	Rohu
9	<i>Puntius sarana</i>	Greenstripe barb	-
10	<i>Puntius sophore</i>	Poolbarb	Dhebri
11	<i>Salmophasia bacaila</i>	Large razorbelly minnow	Chela
12	<i>Glossogobius giuris</i>	Tank goby	-
13	<i>Aurigequula fasciata</i>	Striped ponyfish	Chandro
14	<i>Notopterus notopterus</i>	Bronze featherback	Patra
15	<i>Trichogaster fasciata</i>	Giant gourami	Katiyo
16	<i>Parambassis ranga</i>	Indian glassy fish	Chandro
17	<i>Gambusia affinis</i>	Mosquitofish	-
18	<i>Callichrous microphthalmus</i>	Indian butter-catfish	Jharakho
19	<i>Mystus gulio</i>	Long whiskers catfish	Khagi
20	<i>Heteropneustes fossilis</i>	Stinging catfish	Singhi
21	<i>Terapon jarbua</i>	Tiger perch	-
22	<i>Nematopalaemon tenuipes</i>	Spider prawn	-
23	<i>Macrobrachium rosenbergii</i>	Giant Freshwater Prawn	Jhinga
24	<i>Metapenaeus kutchensis</i>	Ginger Shrimp	Jhinga

However, according to our knowledge, local administration has put legal ban on fishing in some part of Gosabara wetland complex. Therefore, there are only few families of fishermen who regularly carryout fishing in some creek areas. Apart from above mentioned fresh water and marine fishery species no other faunal species were considered economically important species from this wetland.

Threatened Species and Other Species of Conservation Significance

6. TASK-6. IDENTIFICATION OF THREATENED AND CONSERVATION SIGNIFICANCE SPECIES

As per our primary survey we identified threatened species as per IUCN Red list categories (Critically Endangered, Endangered and Vulnerable) (IUCN 2014) and also Schedule-I species listed as per Wildlife Protection Act 1972. During our survey we found total 23 important species which either belongs to IUCN threatened categories or classified as Schedule-I species under Wildlife Protection Act 1972 or both.

Table-6.1: Threatened and Schedule-I faunal species found in Gosabara wetland complex.

No	Species	Scientific Name	IUCN	WPA Schedule
1	Indian flapshell	<i>Lissemys punctata</i>	LC	I
2	Bengal Monitor lizard	<i>Varanus bengalensis</i>	LC	I
	Birds			
3	Black Kite	<i>Milvus migrans</i>	LC	I
4	Black-shouldered Kite	<i>Elanus caeruleus</i>	LC	I
5	Brahmini kite	<i>Haliastur indus</i>	LC	I
6	Egyptian Vulture	<i>Neophron percnopterus</i>	EN	I
7	Indian Peafowl	<i>Pavo cristatus</i>	LC	I
8	Indian Spotted Eagle	<i>Clanga hastata</i>	VU	I
9	Montagu's Harrier	<i>Circus pygargus</i>	LC	I
10	Oriental Honey-buzzard	<i>Pernis ptilorhynchus</i>	LC	I
11	Osprey	<i>Pandion haliaetus</i>	LC	I
12	Pallid Harrier	<i>Circus macrourus</i>	NT	I
13	Peregrine Falcon	<i>Falco peregrinus</i>	LC	I
14	Short-toed Snake Eagle	<i>Circaetus gallicus</i>	LC	I
15	Steppe Eagle	<i>Aquila nipalensis</i>	LC	I
16	Western Marsh Harrier	<i>Circus aeruginosus</i>	LC	I
17	White-eyed Buzzard	<i>Butastur teesa</i>	LC	I
18	Eurasian Spoonbill	<i>Platalea leucorodia</i>	LC	I
19	Common Pochard	<i>Aythya ferina</i>	VU	IV
20	Dalmatian Pelican	<i>Pelecanus crispus</i>	VU	IV
21	Sarus Crane	<i>Antigone antigone</i>	VU	IV
22	Woolly-necked Stork	<i>Ciconia episcopus</i>	VU	IV
	Mammals			
23	Indian Wolf	<i>Canis lupus pallipes</i>	EN	I

Of these, 2 species are Endangered (Indian Wolf and Egyptian Vulture), total 5 bird species are Vulnerable (Common Pochard, Indian Spotted Eagle, Sarus Crane, Woolley necked Stork and Dalmatian Pelican) and total 19 species are listed under Schedule-I of Wildlife Protection Act 1972 in Gosabara wetland complex. These species being categorized as Vulnerable by IUCN and Schedule-I under Wildlife Protection Act 1972 shall be considered as species of

high conservation significance (Table-6.1). Apart from these species no other important species of relatively higher conservation significance were found in Gosabara wetland complex.

Invasive Species of Wetland & Conduct Detailed Population Studies of the Most Significant Species

7. TASK-7. IDENTIFY INVASIVE SPECIES OF WETLAND & CONDUCT DETAILED POPULATION STUDIES OF THE MOST SIGNIFICANT SPECIES

As per definition of Invasive species by **Convention on Biological Diversity**-
"An invasive alien species (IAS) is a species that is established outside of its natural past or present distribution, whose introduction and/or spread threaten biological diversity"

In order to confirm the status and distribution of the identified species in the present study, we referred to various literature, books and websites. We referred to Fauna of Gujarat Part-I (ZSI 2001) Fauna of Gujarat Part-I (ZSI 2004), for confirming the status and distribution of majority of the species observed in the present study. Apart from these, we also reviewed status and distribution of identified species on IUCN redlist website (<http://www.iucnredlist.org>), Birdlife International Website (<http://datazone.birdlife.org>) etc. to reconfirm the status and distribution of the species observed in the present study.

After careful review of literature and websites, we found that none of the identified species. All the species are native to Indian region and no introduced species of fauna were recorded from Gosabara Wetland Complex.

Species Names in English as well as in Local Language

8. TO THE EXTENT POSSIBLE DOCUMENT SPECIES NAMES IN ENGLISH AS WELL AS IN LOCAL LANGUAGE.

Most of the species names are given in English along with their scientific names. However, we have listed some of the local names of fish, birds etc. In local language.

detailed Ecological Analysis of the Key Species Interactions and Ecological Significance in the Wetlands

9. TASK-9. KEY SPECIE INTERACTIONS AND ECOLOGICAL SIGNIFICANCE

9.1. KEY SPECIES INTERACTION

Detailed scientific analysis of key species interactions would require large data sets of several repeat seasons on feeding, breeding and habitat use etc. The present study was scheduled for one year duration only therefore, the required data set was not available to carryout meaningful key species interaction. Based on primary observations and general species information we provide a qualitative matrix of species interactions (Table-9.1).

9.2. SIGNIFICANCE OF GOSABARA WETLAND COMPLEX

- Based on our observations and survey results as well as literature survey we conclude that Gosabara wetland complex is a unique and important coastal wetland for conservation of wetland biodiversity.
- Apart from variety of ecological functions that this wetland is performing, the most important one is the habitat it provides to the great density and diversity of migratory and resident birds for their feeding, roosting, resting and breeding (resident) waterbirds. Therefore, this wetland deserves to be designated as wetland of international importance on Central Asian Flyway of migratory birds. This wetland fulfils several Ramsar Criteria for being identified as wetland of international importance.
- Wetland regularly supports 2 Endangered species such as Indian Wolf and Egyptian Vulture, One Vulnerable species i.e. Indian Spotted eagle and 4 Vulnerable species i.e. Common Pochard, Dalmatian Pelican, Sarus Crane, Woolly-necked Stork therefore it qualifies Ramsar site criteria no-2.
- Gosabara wetland complex fulfils Ramsar site criteria no-5 because it regularly supports more than 20,000 birds. It supported 94,204 waterbirds in 2015, 39738 waterbirds in 2016 and 53237 waterbirds in 2017.
- Gosabara wetland complex fulfils Ramsar site criteria no-6 as it supported 1% population of 32 species of migratory and resident waterbirds. This number i.e. 1% population of 32 species is by far the largest in any wetlands of Gujarat. Of these 32 species 5 are Near Threatened, one is Vulnerable and rest 26 are Least Concerned. One species i.e. Eurasian Spoonbill is Schedule-I species protected under Wildlife Protection Act 1972.
- Gosabara wetland can be considered as one of the major crane roosting sites on Central Asian Flyway. Our study reported roosting of more than 70,000 Demoiselle Cranes and above 20,000 Common Cranes (Eurasian Crane) in Gosabara. This wetland does not provide feeding ground to cranes, they only roost in wetland as it is a vast open, shallow water which provides them safe and undisturbed roosting site. The large concentration of cranes in this wetland in winter is due to the agriculture practices in the surrounding area. The groundnut crop is predominant during monsoon in the surrounding area of Gosabara wetland which is harvested in winter. Post harvest in winter time the fields are left fallow, this is when cranes arrive in large number and exploits remaining groundnut from the fields. It is a matter of research whether the exploitation of residual groundnut seeds post harvest is

beneficial to farmers or not. If that is true than it would be big boost for conservation of migratory cranes in this region and elsewhere. Removal of residual groundnut is likely to reduce chances of growth of insects and fungi such as *Aspergillus* which produces Aflatoxin. A message on how cranes are beneficial to farmers shall be spread for promoting conservation of cranes.

- Gosabara wetland complex with great diversity of birds i.e. more than 230 species of birds (118 terrestrial bird species and 112 waterbird species) along with large congregations of 2 species flamingos, 2 species pelicans, 2 species cranes, and flocks of ducks, waders, gulls, terns has become a favourite destination for birdwatchers. This ornithological assemblage provides great opportunities for eco-tourism and economic benefits to the government and local people.

Table-9.1: Key species interaction qualitative analysis.

Species	Species Characteristics				Sanctuary Habitats			Species role & interactions in Ecosystem			
	Habit	Habitat	Activity	Niche	Breeding	Feeding	Roosting/residing	Trophic	Interaction with plants	Interaction with animals	Impacts in ecosystem
Indian wolf	Carnivore	Dense Prosopis	Nocturnal	Specialist	?	?	Yes	Tertiary Consumer	Uses dense bushes and tall grasses of wetland area for shelter	Wolf as predator is present but no evidence of its predation. Sometime hunted by dogs	Positive, as it could regulate population of large herbivores such as Nilgai and Wild Pigs.
Nilgai	Herbivore	Dense Prosopis	Diurnal	Generalist	Yes	Partial	Yes	Primary Consumer	feeds on Prosopis pods/ causes crop damage in surrounding agriculture area	Wolf as predator is present but no evidence of its predation. Sometime hunted by dogs	Negative, Promotes invasive plant growth. Also affects socio-economic of farmers in peripheral area
Wild pig	Omnivore	Dense bushes	Diurnal	Generalist	Yes	Yes	Yes	Primary & secondary Consumer	feeds on Prosopis pods/ plant roots/ causes crop damage in surrounding agriculture area	No natural predators in eco-system. Sometime hunted by dogs	Negative, Promotes invasive plant growth. Also affects socio-economic of farmers in peripheral area
Honey bees, Ants	Nectivores, Pollen feeder	Trees and plants	Diurnal	Specialist	Yes	Yes	Yes	Primary Consumer	Feeds on nector and promotes pollination	competes with nectivore birds, becomes food for other birds	Positive, Important pollinators
Cranes	Omnivore	open wetland	Diurnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on roots, tubers, groundnut, cereals,	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Water birds	Herbivore, Piscivore, Omnivore	open wetland	Diurnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on fish, algae, insects, crabs	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Terrestrial birds	Granivore/ Insectivore/ Carnivore	Trees, Open scrubland, dense vegetation	Diurnal/ Nocturnal	Specialist	NO	Yes	Yes	Primary Consumer	Feeds on fish, algae, insects, crabs	Becomes food for carnivores such as Jungle cat, Jackals etc.	Positive, Nutrient cycling in food web and important tourist attraction
Insects	Herbivore/ Omnivore	variety of microhabitat		Generalists & specialists	Yes	Yes	Yes	Pri & Secon Consumers	Feed on plants, leaves, pollen, etc	Becomes food for birds and animals	Positive, Nutrient cycling and important role in food web

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Annexure-I

Details of field visits carried out by various experts for biodiversity sampling.

No	Start Date	End Date	Days	Person/ Expert	Expertise/Sampling
Insects Sampling					
1	27/12/2015	28/12/2015	2	Dr. Kiran Ahir	Insects Sampling
2	11/2/2016	13/2/2016	2	Dhaval Varagya	Insects Sampling
3	15/8/2016	16/8/2016	2	Dr. Kiran Ahir	Insects Sampling
4	15/8/2016	20/8/2016	5	Dhaval Varagya	Insects Sampling
Fish & other Aquatic Fauna Sampling					
1	9/3/2016	10/3/2016	1	Mayurdan Gadhvi	Fish & Aquatic animals
2	28/4/2016	29/4/2016	1	Mayurdan Gadhvi	Fish & Aquatic animals
3	28/4/2016	29/4/2016	1	Kangkan Jyoti Sharma	Fish & Aquatic animals
4	20/7/2016	23/7/2016	3	Mayurdan Gadhvi	Fish & Aquatic animals
5	20/7/2016	23/7/2016	3	Kangkan Jyoti Sharma	Fish & Aquatic animals
6	15/8/2016	17/8/2016	2	Mayurdan Gadhvi	Fish & Aquatic animals
7	11/2/2016	13/2/2016	2	Mayurdan Gadhvi	Fish & Aquatic animals
8	11/2/2016	13/2/2016	2	Kangkan Jyoti Sharma	Fish & Aquatic animals
9	19/2/2016	20/2/2016	1	Mayurdan Gadhvi	Fish & Aquatic animals
Herpetofauna Sampling					
1	27/1/2016	30/1/2016	4	Dr. Virag Vyas	Herpetofauna
2	26/7/2016	29/7/2016	4	Dr. Dishant Parasharya	Herpetofauna
3	26/7/2016	29/7/2016	4	Mr. Vinod Gajjar	Herpetofauna
Terrestrial birds & Mammals					
1	27/12/2015	31/12/2015	5	Dr. Chittaranjan Dave	Terrestrial birds & Mammals
2	9/3/2016	11/3/2016	3	Dr. Chittaranjan Dave	Terrestrial birds & Mammals
3	27/4/2016	29/4/2016	3	Dhaval Varagya	Terrestrial birds & Mammals
4	30/4/2016	3/5/2016	3	Dhaval Varagya	Terrestrial birds & Mammals
5	5/5/2016	5/7/2016	3	Dhaval Varagya	Terrestrial birds & Mammals
Waterbird & Team Leader (Assistance in other taxa sampling)					
1	27/12/2015	31/12/2015	5	Dr. Bharat Jethva	Waterbirds & TL
2	27/1/2016	30/1/2016	3	Dr. Bharat Jethva	Waterbirds & TL
3	9/3/2016	11/3/2016	3	Dr. Bharat Jethva	Waterbirds & TL
4	27/4/2016	29/4/2016	3	Dr. Bharat Jethva	Waterbirds & TL
5	27/5/2016	28/5/2016	2	Dr. Bharat Jethva	Waterbirds & TL
6	15/8/2016	17/8/2016	3	Dr. Bharat Jethva	Waterbirds & TL
7	2/11/2016	3/11/2016	2	Dr. Bharat Jethva	Waterbirds & TL

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. Faunal biodiversity surveys for Baseline Assessment at Gosabara Wetland Complex in Gujarat were conducted by a team of experts from the Green Support Services, during 2015 -16. The study presents the results of the characterization of faunal biodiversity of Gosabara wetland complex. The results are intended to support the effective management planning of this wetland, which is suitable for being designated as the wetland of International Importance.

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.

Faunal Biodiversity Survey for Baseline Assessment of Gosabara Wetland Complex in Gujarat

August 2017