ECOLOGICAL ASSESSMENT OF FAUNA

at Manchhar Lake, District Dadu, Sindh

Baseline Survey 2010 - 2011

Contents

List of Acronyms 6
EXECUTIVE SUMMARY 9
CHAPTER 1 – INTRODUCTION 11
1.1 Introduction 12
1.1.1 Introduction to Manchhar Lake 12
1.1.2 State of biodiversity 12
1.2 Rationale and objectives 13
1.2.1 Large Mammals Survey 13
1.2.1.1 Rationale 13
1.2.2.1 Objectives of the study: 14
1.2.2 Small mammal survey 14
1.2.2.1 Rationale 14
1.2.2.1 Objectives of the study: 17
1.2.3 Reptiles and amphibians 17
1.2.3.1 Rationale 17
1.2.4.1 Objectives of the study: 18
1.2.4 Birds 18
1.2.4.1 Rationale 18
1.2.4.2 Objectives of the study: 18
1.2.5 Physico-chemical properties of water 19
1.2.5.1 Objectives of the study 19
CHAPTER 2 – MATERIAL AND METHODS 20
2.1 Large Mammals 20
2.1.1 Team Composition 20
2.1.2 Point surveys 20
2.1.3 Roadside Counts 20
2.1.4 Track Counts 20
2.1.5 Line transects 21
2.1.6 Pellet counts 21
2.1.7 Interviews with local residents 21
2.1.8 Equipments and Field Kit 22
2.2 Small Mammals 22
2.2.1 Bait 22
2.2.2 Traps and trapping procedure 22
2.2.3 Data collection 23
2.3 Reptiles and amphibians 23
2.3.1 Survey method 23
2.3.2 Active searching 23
2.3.3 Trapping 24
2.3.4 Signs 24
2.3.5 Collection 24

2.3.6 Data Records 24
2.3.7 Preservation 25
2.3.8 Identification of species 25
2.3.9 Data Analysis 25
2.4 Birds 26
2.4.1 Survey Method 26
2.4.2 Evaluation of water bird numbers 26
2.4.3 Methods of accurate count 27
2.5 Physico-chemical Properties of Water 27
CHAPTER 3 – FINDINGS AND DISCUSSIONS 28
3.1 Large Mammals 28
3.1.1 Sampling locations 28
3.1.2 Species identified 28
3.1.1 Observation Records 29
3.1.1 Conservation Status of Recorded Mammals 29
3.1.5 Threats and recommendations 30
3.1.5.1 Threats 30
3.1.5.2 Recommendations 30
3.2 Small Mammals 30
3.2.1 Sample locations 30
3.2.3 Feeding habits 31
3.2.4 Habitat and occurrence 32
3.2.5 Threats and recommendations 34
3.2.5.1 Threats 34
3.2.5.2 Recommendations 34
3.3 Reptiles and amphibians 34
3.3.1 Sample locations 34
3.3.2 Summary 34
3.3.3 Species richness 36
Shannon's Index: 37
3.3.4 Threats and recommendations 42
3.3.4.1 Threats 42
3.3.4.2 Recommendations 42
3.4 Birds 43
3.4.1 Sampling locations 43
3.4.2 Summary 43
3.4.3 Species account 43
3.4.3.1 Winter and Summer 44
3.4.4 Summer and winter account 48
3.4.5 Threats and recommendations 51
3.4.5.1 Threats 51
3.4.5.2 Recommendations 52
3.5 Physico-chemical Properties of Water 52
3.5. 1 Sample Location 52
3.5.2 Field Observations during water sampling 52
3.5.3 Results 52

CHAPTER 4: COMPARISON OF THE FOUR STUDY SITES 57
Mammals 57
Summary: 57
Species identified 58
Species Diversity 60
Comparison of Species observed during summer and winter 60
4.2 Small mammals 65
4.2.1 Species recorded 65
4.2.2 Feeding habits 67
4.2.3 Habitat 70
4.3 Reptiles and amphibians 71
4.3.1 Summary 71
4.3.2 Species recorded 72
4.3.3 Species diversity 75
4.4 Avi-fauna 76
4.4.1 Summary 76
4.4.1.1 Nara Wetland Complex 76
4.4.1.2 Manchar Lake 76
4.4.1.3 Kharochann 77
4.4.1.4 Khyberani Forest 77
4.4.2 Species recorded 78
Bibliography 89

LIST OF TABLES

Table 1 – Mammals recorded from Manchar Lake area 29
Table 2 – Observation records of different mammal species from Manchar Lake 29
Table 3 – Conservation status of mammals found at Manchar Lake 29
Table 4 – Species recorded at Manchar Lake along with conservation status, feeding and activity habits 31
Table 5: Reptilian and Amphibian Species of Manchhar 35
Table 6 – Diversity indexes for reptiles and amphibians recorded from Manchar 40
Table 7 – List of bird species recorded from Manchar 44
Table 8 –Chemical analysis test result of water of Goth Bubak and Manch 53
Table 9 – Chemical analysis result of water of Zero point , Manchhar 53
Table 10 –Chemical analysis of water of outlet shawan, Manchhar 54
Table 11- Microbiological Analysis Result 55
Table 12- Species recorded from different sites 58
Table 13 Observation Record of Large Mammals 58
Table14 Conservation status of mammals found at sites 59
Table 15 -Mammals observed at Nara Wetlands Complex during summer and winter Surveys 61
Table 16 -Mammals observed at Khyberani Forest during summer and winter surveys 61
Table 17 -Mammals observed at Manchhar Lake during summer and winter surveys 61
Table -18 Mammals observed from Kharochann during summer and winter surveys 61
Table 19 Assessment of level of threats to mammals at different study sites 63

Table 20 - Threats Ranking for Large Mammals at Sites 64
Table 21- LIST OF SMALL MAMMAL SPECIES RECORDED FROM EACH SITE 66
Table 22 - LIST OF REPTILES AND AMPHIBIA SPECIES RECORDED FROM EACH SITE 73
Table 23 – Species Diversity 75
Table24 – Total number of bird species recorded at each site 78
Table 25 - LIST OF BIRD SPECIES RECORDED FROM EACH SITE 78

List of Figures

Figure 1 – Distribution of feeding types across the species recorded at Manchar Lake .. 32
Figure 2 – Number of species recorded from habitat types 32
Figure 3 – Distribution of small mammal status over the species and season at Manchar Lake 33
Figure 4 – Number of reptile and amphibian species recorded during summer and winter from Manchar Lake 40
Figure 5 – Shannon and Margalef indexes for summer and winter at Manchar Lake 41
Figure 6 – Number of species, families and orders observed during winter and summer season 48
Figure 7 – The abundance of the number of species during the summer and winter season 49
Figure 8 – Representation of birds recorded during the two seasons 50
Figure 9 – Number of bird species recorded from Manchar against season and occurrence 50
Figure 10 - Shannon diversity and Evenness index over all sites for summer and winter 62
Figure 11 Aggregated threat ranking adjusted against number of species recorded from each site 63
Figure 12 Aggregated score for distribution factors across sites 65
Figure 13 below shows the number of small mammal species recorded at each site over winter and summer. 66
Figure 14 – Percentage of species recorded for each site over feeding habit 67
Figure 15 – Percentage of species recorded for each side over feeding habits 68
Figure 16 – Percentage of species recorded over season against feeding habits 68
Figure 17- Percentage of species observed according to habitat 70
Figure 19 – Percentage of species and total species number recorded from each site 74

List of Acronyms

A	**Abundant**
As	**Arsenic**
BOD	**Biochemical Oxygen Demand**
C	**Common**
CAR	**Carnivore**
Cd	**Cadmium**
CE	**Critically Endangered**
CEMB	**Centre of Excellence in Marine Biology**
CITES	**Convention on International Trade in Endangered Species of Flora and Fauna**
Cl	**Chloride**
Cr	**Chromium**
DO	**Dissolved Oxygen**
DR	**Diurnal**
E	**Endangered**
EIA	**Environmental Impact Assessment**
GEL	**Global Environmental Lab (Pvt) Ltd.**
GIS	**Global Information System**
GPS	**Global Positioning Station**
GRN	**Grainivore**
Ha	**Hectare**
HRB	**Herbivore**
ID	**Index of Density**
IDER	**Indus Delta Eco-region**
IFAP	**Indus for All Programme**
INS	**Insectivore**
IUCN	**The World Conservation Union**
KC	**Kharochann**
KF	**Khebrani Forest**
LC	**Least Concern**
M	**meters**
MAF	**Million Acre Feet**
Mg	**Magnesium**
Mm	**millimeter**
MNVD	**Main Nara Valley Drain**
ML	**Manchar Lake**
NC	**Nocturnal**
NGO	**Non-Governmental Organisation**
Ni	**Nickel**
No.	**Number**
NR	**Natural Resource**

NT	**Near Threatened**
NWC	**Nara Wetland Complex**
P	**Protected**
Pb	**Lead**
Ppt	**particles per thousand**
SWD	**Sindh Wildlife Department**
VU	**Vulnerable**
WHO	**World Health Organisation**
WWF P	**World Wide Fund for Nature Pakistan**

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EXECUTIVE SUMMARY

WWF - Pakistan has initiated Indus Eco-region Programme, which is a 50 year vision. A total of 15 landscapes have been prioritized within the eco-region. Indus for All Programme was initiated in July 2006 with the support from Royal Netherlands Embassy, as a beginning of the implementation of the visionary Indus Eco-region Conservation Programme. Implementation of *Indus for All Programme (IFAP)* at the first instance was implemented on four out of fifteen prioritized landscapes.

The second phase of implementation of *Indus for All Programme* started on another four prioritized landscapes, which are Kharochan (coastal), Manchar Lake (fresh water ecosystem), Khyberani Forest (irrigated forest) and Nara Wetland Complex (wetland ecosystem). The programme aims to work with all relevant stakeholders at field, district, provincial and national levels to build capacity, support and influence planning and mainstreaming of poverty-environment issues.

MancharLake is one of the selected sites for the second phase. It is the largest fresh water lake in Pakistan, situated in Dadu district. It is a vast natural depression flanked by Khirthar range in the west, Lakhi hills in south and river Indus in the east. On the north eastern side is the protective embankment. The lake is fed by two canals, the Aral Wah and the Danister from the river Indus. The lake also collects water from numerous small streams in the Khirthar Mountains.

The area of the lake fluctuates during the flood season from 350 to 520 km^2. The mean depth of the lake is at present 13 feet. The lake was created in the 1930s when the Sukkur Barrage was constructed on the river Indus. During summer monsoon, rain water from the Khirthar mountainsgenerally flows through numerous hill torrents such as Gaj nai, Naing nai, Mazarani nai, Khewji nai, Sita nai and Salari nai. When supply of water from the hills is adequate to cover the whole area of the lake, both Aral and Danister canals then serve as outlet.

The majority of the community living at and around the lakeare the fisher folk and belong to the ancient Mohanna tribe, locally known as Mirbahars meaning sea lords. They are believed to be descendants of Scythian Meds of Moenjodaro. It was a part of their tradition that they lived as “boat people” in their traditional high powered wooden boats. This tradition is now diminishing but still some boats with dwellers can be seen at Manchar.

There has been continuous environmental degradation of the wetland and water of the lake is becoming saline. The diversion of water from the Indus and run off water from Khirthar mountains have contributed to the reduction in fresh water supplies. Saline drainage water from agricultural fields in surrounding areas also adds to the salinity of the lake. Pollution through the Main Nara Valley Drain (MNVD) is the main threat to the lake. It brings agricultural, municipal, industrial and saline water which is the constant polluting source of the lake. The lake is also facing eutrophication.

The lake and surrounding areas provide habitat for a diversity of life including fishes, migratory birds, reptiles and mammals. The important wildlife habitats include: main lake, lake shore, hilly/stony areas, agricultural areas, mudflats, wasteland, marshes and villages.

It has been an important area for water birds and the waterbirds previously recorded from here include: Little Grebe, Cotton Teal, White Pelican, Common Teal, Shoveler, Common Pochard, Great Crested Grebe, Large Cormorant, Gadwall, Mallard, Tufted Duck, Red-crested Pochard and the Coot. Until recently, the lake was a stop-over on the Indus flyway, but now the numbers have declined drastically. Manchar Lake has multiple habitats, North East is the flat plain and predominantly agricultural and South West is hilly range land. This is a very important wetland due to its socio-economic value.

The lake has been rich in commercial fishing so fish stocks are however drastically deteriorating. Prashad and Mukerji (1930) recorded 36 fish species, Sufi (1962) recorded 43 species, Baig and Khan (1976) reported 40 species and Mehar *et al.* (2000) have reported 32 species including an exotic species, tilapia *Oreochromis mossambicus.* The important commercial fish species found in the lake include the major carps *(Labeo rohita, Catla catla* and *Cirrhinus mrigala)*, cat fish *(Wallago attu* and *Heteropneustes fossilis)*, murrels *(Channa marulius, C. punctatus* and *C. striatus)* and featherbacks *(Notopterus notopterus* and *N. chitala)*.

Surveys were conducted in winter 2010and summer2011 to collect the baseline data about the fauna of the area.

Large Mammals: The Mammalian fauna is less diverse in the area. There has been impact of flood of 2010 on the mammals of the area. Their habitat was inundated due to flood resulting in the decline in their population. Five species of large mammals were recorded including the Jackal, Red Fox, Jungle Cat, Small Indian Mongoose and Grey Mongoose.

Small Mammals: The flood has also affected the species and habitats of small mammals. Eight species belonging to 3 orders and 5 families of small mammals were recorded.

Birds: The Lake provides the main habitat to the waterbirds although birds also inhabit the nearby main habitats such as villages, hillocks and near built up areas. Seventy five species of birds belonging to 11 orders and 33 families were recorded. White Pelican, Common Coot and Common Shelduck are the key species of the wetland.

Captured birds are usually kept by the fishermen in and around the lake such as Grey Heron, Large Egret, Intermediate Egret, Large Cormorant, White Pelican, Spoonbill, Reef Heron and Black headed Gull.

Reptiles and Amphibians: Seventeen species of Reptiles belonging to 4 orders and 9 families have been recorded including10 insectivorous and 7 carnivorous species.

The key species include the Indian Flap-shell Turtle, Brilliant Agama, Indian Monitor, Yellow-headed Rock Agama and Snake eyed Lacerta. There is a threat to the freshwater turtles due to pollution in the lake. There are roadside kills of Monitor Lizards.

Two species of amphibian viz. Skittering Frog and Indus valley or Marbled Toad have been recorded.

The main threats to the biodiversity include: eutrophication, excessive cattle grazing, domestic sewage, hunting and trapping of birds, oil pollution, and tourism/recreation.

The lake had lost its significance as waterbird habitat due to the effect of pollution on the water quality of the lake during the preceding years but the influx of heavy floods in August 2010, brought about some positive changes to the wetland by improving water quality at least for the time being. The wetland has now temporarily revived.

CHAPTER 1 – INTRODUCTION

1.1 Introduction

Manchhar is the freshwater perennial lake located in Dadu district. It is one of the largest freshwater lakes in Asia and spreads over an area of about 200 sq. km. Its surface area varies from about 19,000 acres in dry season to 63,000 acres in rainy season. Since 1980si the lake is being degraded and is now a threatened wetland, dying from pollution, toxic effluents and mismanagement. The main Nara Valley Drain (MNVD) brings agricultural, municipal, industrial and saline water and drains into the lake. This is the main source of polluting the lake and the water quality of the lake has changed and deteriorated.

The lake had been a great source of fishes and livelihood of the local community who depended on fish catch. This was the wetland where fishers' families lived on traditional residential boats. There were about 2000 such boats which were the traditional home of fishing community. Now their numbers have reduced to only a few boats due to environmental degradation of the lake and decrease in fish catch from the lake.

There are about 100,000 inhabitants in the area. Fishing is the primary source of livelihood of the local communities that are solely dependent upon Manchar Lake. The environmental degradation of the lake has a significant economic impact on the livelihoods of local communities. The fish catch has declined alarmingly and thus livelihood of local communities has been affected. The migration of local fishers has been continuing and many of them now have migrated to other sites in the country where they can earn their livelihood through fishing.

The lake is the important habitat for birds. It is the wintering ground of waterbirds migrating from Central Asia, following Flyway #4, also known as Indus Flyway. About 50,000 birds of 102 species were recorded during winter counts in 1988. Now only a few thousand migratory birds visit the lake during winter.

1.1.1 Introduction to Manchhar Lake

1.1.2 State of biodiversity

It is a very important area for waterbirds and fishes. The lake itself provides the main habitat to the species along with associated marshes, mudflats, hillocks on sides of lakes, agricultural land, wasteland, built in areas around, and villages such as Goth Shah Hasan and Goth Muhammad Bux Jagirani, tombs of Qaim Shah and Qambar Shah.

The dominant vegetation along the surrounding area of the lake consists of *Phragmites, Suaeda, Tamarix, Aerua, Indigofera* and *Salvadora* spp. along with trees such as Ber, Kandi and Kaner.

Fauna: The Lake harbors a variety of waterbirds and fishes. The surrounding areas provide habitat to some species of mammals, birds, reptiles and amphibians.

- **Mammals:** The mammalian diversity is quite low in the area. 13 species of mammals were recorded. Among the large mammals, Indian Jackal, Red Fox, Jungle Cat, Small Indian Mongoose and Large Indian Mongoose were recorded, while small mammals observed include: Indian Porcupine, Desert Hare, Palm Squirrel, Long-eared Hedgehog, Indian Gerbil, Balochistan Gerbil, Indian Desert Jird and House Mouse.

- **Birds:** It is an important area for waterbirds. Seventy three bird species were recorded during the winter surveys. It has been an important area for supporting large concentration of waterbirds such as 45,306 in the year 1991; 31,852 in 2000; 9,491 in 2001; 8,260 in 2002 and 6,260 in 2003 and 1,183 in 2011.

- **Reptiles:** Fifteen species of reptiles were recorded from the area including Indian Monitor, Desert Monitor, Brilliant Agama, Indian Flap shell Turtle and Indian Cobra.

- **Amphibians:** 2 species of amphibians viz. Marbled Toad and Skittering Frog were recorded from the area.

1.2 Rationale and objectives

1.2.1 Large Mammals Survey

1.2.1.1 Rationale

WWF - Pakistan has initiated Indus Eco-region Programme, which is a 50 year vision. A total of 15 landscapes have been prioritized within the eco-region. Indus for All Programme was initiated in July 2006 with the support from Royal Netherlands Embassy, as a beginning of the implementation of the visionary Indus Eco-region Conservation Programme. Implementation of *Indus for All Programme* at the first instance was implemented on four out of fifteen prioritized landscapes viz. Keti Bunder (coastal), KinjharLake (Fresh water ecosystem), PaiForest (irrigated forest) and Chotiari Reservoir (wetland ecosystem). This programme will continue till June 2012.

The second phase of implementation of *Indus for All Programme* started on another four prioritized landscapes, which are Karochan (coastal), MancharLake (Fresh water ecosystem), KhaibraniForest (irrigated forest) and Nara Wetland Complex (wetland ecosystem). The programme aims to work with all relevant stakeholders at field, district, provincial and national levels to build capacity, support and influence planning and mainstreaming of poverty-environment issues.

The preliminary ecological assessment of the project sites has been initiated as an output of the programme to establish a baseline in and around the abovementioned sites. The baseline will determine key livelihoods interventions of *Indus for All Programme* by identifying the gaps and opportunities.

As a part of the ecological assessment and to study the mammalian fauna of the project sites, the study sites were visited twice; firstly during winter in November – December 2010 and secondly in summer during July 2011. Each visit of all the four sites was of 2-4 days duration.

1.2.2.1 Objectives of the study:

a. Identify various large and medium sized mammals in the study area, develop a checklist and estimate the populations of some key mammalian species.
b. Assess the major threats that are likely to affect the survival of large mammals and suggest mitigation measures to those threats.
c. Identify key habitat and associated features of the large mammals habitat

1.2.2Small mammal survey

1.2.2.1 Rationale

Small mammals are an indispensable component of fauna and they play an important role in determining the holding capacity and maintenance of the number of animals in the higher trophic level of the food chain. They not only maintain ecological balance in an ecosystem, but also play a specific role in biological control, necessary for a self sustained ecosystem. These small animals fill niches and depend upon the submerged roots, fallen seeds, rhizomes and bulbs, insects, snakes, scorpions, spiders and beetles for their food. They are in turn eaten by larger animals like foxes, jackals, cats, owls, eagles, kites, falcons and wolves living in a particular ecosystem. To determine the status of large mammals it is necessary to obtain data on small mammals.

Role of small mammals usually stem from perceived negative values associated with their role as pest and disease spreading animals. Small mammals however, play an important and perhaps indispensable role in the functioning of an ecosystem. They should not be viewed separately from other components of the ecosystem. Rather, they must be viewed in terms of their interrelationships with other components. Small mammals influence the structure and function of ecosystems as consumers of plants and small animals as movers of soil and soil nutrients, and as the primary prey of raptors, snakes, hawks, eagles, owls and carnivorous mammals. Because of their intermediate trophic position and high dispersal abilities, small mammals may track changes in biotic and abiotic environment that result from shifts in land use practices and other human activities.

Researchers have proposed various ways in which small mammals interact with plant communities. The main interactions can be categorized as those relating to primary productivity, plant species composition, plant stature and reproduction and decomposition rates of plant materials. Small mammal herbivores may consume as much as 60% (Migula *et al.* 1970) of the total annual primary plant production. They may have localized, large scale impacts on primary productivity during population explosions. However, the effect of direct consumption of plants by herbivores must be evaluated in terms of what portion of the primary production is actually available to the animal. Estimates of vegetation consumption by small mammals ranged from <1% in short grass and mid grass sites to as much as 20% in desert grasslands (French *et al.* 1976). Harris (1971) has estimated that 0.17-5.01% of the net primary production was transferred to the rodent trophic level.

Small mammals have been credited with changing plant community composition and species distribution. Plant communities in many parts of USA have been altered by extensive damage to big sage brush during cyclic population peaks of voles. Control of pocket gophers in western Colorado resulted in an increase of perennial forbs (Turner 1969) while grass and sedge densities were higher in areas where gophers were present. Small mammals can also alter plants community composition and species distribution by consuming and caching seeds. They can also influence plant community composition by heavily grazing or damaging plants, and thus reducing their ability to produce seeds.

Seed caching activities of small mammals can alter plant distribution by either increasing or decreasing survival of plants. Yet, dispersal of seeds by small mammals can result in increased germination and survival. Some organisms may be dependent on small mammals for seed or spore dispersal. Many fungi and nitrogen fixing bacteria and yeast depend on small mammal mycophagy for spore dispersal (Fogel and Trappe 1978).

The rate of plant succession may be affected by small mammal burrowing and feeding activities. The mounds of small mammals disrupt grass associations and provide bare soil for the invasion of lower succession plants, thereby increasing the diversity of plants. Selective herbivore by small mammals can also alter plant succession rates. Rodents may aid in the recovery of overgrazed grasslands by selectively grazing on weedy plant species (Gross, 1969).

Small mammals can influence the rate of decomposition of organic materials by adding green herbage and excrements to the litter layer and by reducing the particle size of vegetative material. They are more efficient in effecting the mineralization of organic matter than either insects or ungulates (Golley *et al.* 1975). Voles affect decomposition rates by altering microclimatic conditions in the litter layer and by deposition of excrements and vegetative cuttings into litter layers, which increases micro-organism growth (Zlotin and Kodashova 1974). Reduction of particle size of living and dead vegetative material by small mammals also increases decomposition rates.

Soil structure and chemical composition are affected by the activities of small mammals. Burrowing activities largely influences soil structure. Burrowing and the addition of feces

and urine to the soil influence soil chemical composition through changes in nutrient and mineral cycling rates and pathways. Soil structure may be altered as small mammals burrow, bringing large quantities of mineral soil to the surface. Pocket gophers are reported to excavate 18 metric tons of soil material per hectare per year (Hole 1981). Abaturov (1968) estimated that mole burrows covered 36% of woodland ground surface, which resulted in increased soil porosity and drainage, and altered soil water holding capacities. Soil mounds resulting from small mammal burrowing are strongly heated and the surface crust that rapidly forms prevents evaporation. As a result, at depths of 5-20 cm the water content of the soil under mounds is 7 – 82 higher than at corresponding depths in virgin soil (Zlotin and Kodashova 1974).
The most significant role of small mammals may be their effect on the chemical composition of soils, particularly the addition and incorporation of nitrogen. Soil chemical composition can be altered by the addition of excreta and by upward displacement of nutrients through the soil profile.

Small mammals function as secondary consumers in the ecosystem by preying on invertebrates and on other mammals, which may have direct impacts on prey production. Insectivorous species may exert a regulatory effect on invertebrate populations; small mammals consumed a high percentage of invertebrate populations in nearly all grassland sites studied by French *et al* (1976). Carnivores have been shown to influence prey species densities. Hayward and Phillipson (1979) estimated that weasels consumed as much as 14% of the small mammal production, resulting in a reduction in the impact of small mammals on the rest of the ecosystem. Secondary consumption may indirectly influence primary production. Plant consumption by invertebrate herbivores may be reduced by the insectivorous feeding habits of small mammals. Destruction of small mammal predation may serve to reduce invertebrate species that are themselves predators of phytophagous insects. Small mammals also affect Land bird species. Nest predation by small mammals is the major cause of nest failure in passerines and nesting success of land birds.

Small mammals serve as a food supply for a large number of predators and can exert significant influence on predator population cycles. Small mammals, especially rodents are characterized by high productivity rates, and thus even at relatively low densities, are an important source of food for predators. Densities of small mammals can have profound impacts on the reproductive potential of some predators. For example, the proportion of tawny owls that bred each year in England varied from 0 to 80% according to the number of mice and voles present (Southern, 1970). Several authors have documented cases where population levels of predators can be traced to small mammal densities. For example, population declines in black-tailed jackrabbits *(Lepus callfornicus)* induced significant decreases in numbers of coyotes *(Canis latrans)* in north-western Idaho and southern Idaho (Clark 1972) and kit foxex (Vulpes macrotis) in western Utah (Egoscue, 1975). Raptors, such as the great horned owl, may increase as much as five-fold during years of high densities of snowshoe hares in Alberta (Mclnvaille and Keith, 1974). Further, population outbreaks of small mammals can induce predators to switch from preferred prey, thus reducing predation on some game species.

1.2.2.1 Objectives of the study:

a. Collect data from the field on species occurrence, abundance and diversity of the study areas;
b. Collect and review secondary data on small mammal species of the study sites, using the available literature and knowledge of the local inhabitants.
c. Prepare a taxonomical checklist of the species of small mammals based on field observations, sampling and secondary data.
d. Identify threatened mammalian species in the Indus for All Programme sites and recommend conservation measures;
e. Study the behaviour of various species of rodents and other associated groups in relation to the habitat and diet in the study sites.
f. Assessment of impacts of environmental changes and human population pressure on potential mammalian species and their habitats. Associated mitigation measures are to be suggested.
g. To identify the key species of small mammals inhabiting the area.
h. To identify impact of small mammals on the overall livelihood of the people.

1.2.3Reptiles and amphibians

1.2.3.1 Rationale

Reptiles and amphibians are important vertebrate fauna. Amphibians show the transition from aquatic to terrestrial life. Apart from their impressive evolutionary history, they demonstrate different concepts of physiological and behavioral adaptations to different climates, from tropical forests to hot deserts and marine to fresh water. They do not have the ability to travel long distances like birds and mammals. In response to any local environmental changes they respond quickly and therefore may act as excellent biological indicators.

Amphibians and reptiles are important components of any living system and play a key role in the interlocking web of nature. At one end they prey upon insects and other invertebrates and therefore regulate the population of these animals and on the other hand they are also a major source of food for other carnivore species (birds and mammals). Their position in the ecological niche is so vulnerable that the survival and collapse of the whole energy cycle depends upon the presence and absence of amphibians and reptiles. The existence and sustainable use of this biological resource is therefore imperative around the study sites.

Despite the fact that amphibian and reptiles are an important biological resource, very little attention has been paid to them in Pakistan. The major hurdle presumably is the lack of expertise and awareness in this particular field. Moreover, our society in general and

rural folk in particular is mostly repulsive and afraid of reptiles. The results of the present study will provide information on reptiles and amphibians of the Programme sites. Furthermore, the status of all the species of Amphibians and Reptiles will be evaluated so that in any adverse circumstances the conservation strategies could be suggested.

1.2.4.1 Objectives of the study:

a. Collect and review secondary data on the reptile and amphibian species of the study sites, using the available literature and local inhabitants.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas.
c. Prepare a taxonomical checklist of all the species with their English and local names and their status in the study sites.
d. Identify threatened amphibian and reptile species in IFAP sites and recommend measures to improve the situation.
e. Study the behaviour of various species of amphibians and reptiles in relation to habitat and diet in the study sites.
f. Assessment of impacts from environmental changes and human population pressure on potential reptilian and amphibian species and their habitat and to suggest associated mitigation measures.

1.2.4Birds

1.2.4.1 Rationale

Birds are natural indicators of the health of an ecosystem. When birds disappear from an area or have declining trend in population, it indicates the deteriorating health of the ecosystem.

The area of Indus valley is known as the best part of Pakistan for waterfowl (Koning 1987) with large areas of southern deltaic zone annually inundated during the monsoon season whilst in winter and spring the water recedes, evaporates or is used for agricultural purpose, such conditions being ideal for wintering scores of waterfowl.

The study aims to conduct ecological assessment of the avifauna in order to establish a baseline of IFAP proposed sites.

1.2.4.2 Objectives of the study:

a. Conduct a review of literature on bird fauna
b. Develop a species inventory of the resident and migratory birds with notes on relative occurrence and distribution of each programme area

c. Conduct a site specific study on main habitats important to bird species including habitats of critical importance.
d. Record human impact on resident and migratory bird population.
e. Document and describe bird species of "Special Concern" with economical and ecological perspective both in resident and migratory avifauna found within the study site.
f. Conduct studies to describe and assess anthropogenic impacts on bird species founding the study area.

1.2.5 Physio-chemical properties of water

1.2.5.1 Objectives of the study

a. Review and complete baseline surface hydrological conditions, baseline ground water conditions, baseline of water quality levels in the area;
b. Collect accurate field measurements for pH, Zinc, Cyanide, Nitrate, C.O.D., oil and grease, conductivity, light transparency/turbidity, total Coli forms, Fecal E. coli, hardness, fecal Enterococci/Streptococci, Chlorides, Arsenic, and alkanity according to approved procedures;
c. Analyse data to identify water quality contaminants of concern levels and extent of contaminating to determine ambient conditions, trending and cause/effect relationships for each area.

CHAPTER 2 – MATERIAL AND METHODS

2. MATERIAL AND METHODS

Faunal data was collected by different methods for each group of animals as described below. During field work, locations within the different habitats that exist in the area were sampled. The sampling locations were randomly selected, ensuring that in each habitat type sufficient location are sampled so that maximum number of species could be encountered and recorded.

2.1 Large Mammals

2.1.1 Team Composition

The study team comprising of 2-3 members conducted surveys during winter and summer. Detail of survey team is given in the annex document.

2.1.2 Point surveys

In this method, observation points were established along roads, edges of ponds or marshes, at a higher place or at any other location suitable for viewing the habitat. For a period of 15 to 60 minutes at each observation point, the observer recorded all sightings of the mammals at that site.

2.1.3 Roadside Counts

Usually it is difficult to locate a large mammal by walking in its habitat, as it can smell the human from a long distance. Hence the method of roadside counts was applied mostly for the nocturnal mammals like foxes, jackals, cats, hog deer and wild boar as well as for the diurnal mammals like mongoose. For this purpose, 4x4 vehicles were used which were driven at a slow speed (7 km/hr). These roadside counts were carried out during early morning at dawn and during night by using search lights.

2.1.4 Track Counts

Tracks can be the first indication of the presence of animals in an area. Track counts especially after rain can be useful in identifying different animals especially those which are nocturnal and secretive in habits. A fresh rain eliminates the previous tracks and the recent tracks of animals entering or leaving the study area can be used as a measure of their abundance.

During the survey period, track count technique was applied at all the four study sites and this method proved very effective to determine the present of cats, otters etc.

2.1.5 Line transects

The line transect or strip census method of population estimation involves counting the animals seen by an observer traversing a predetermined transect line and recording the animal and distances on the both side of the strip at which they were observed. The length of the strip multiplied by the average total distance of both sides of the strip is the sample area.

Line transects or strip census method is particularly useful technique when animals are difficult to and must be flushed to be observed and recorded.

2.1.6 Pellet counts

Pellets' counting in a specific area is a good technique for locating large mammals and assessing their populations. The technique involves removing all pallet groups from plots and then estimating from subsequent observations on those plots and number of groups per hectare to compare animal use of areas between sampling periods. In some cases it is not possible to remove all the pellet groups from an area therefore under such circumstances; an observer with a little practice can identify the fresh pellets depending on the color and dryness of the pellets. Ten to fifteen 100 m² plots (7.07 x 14.14) can be used for this purpose. These plots should be checked every three to seven days and the periods between samplings should not be so long that feces will decompose or be destroyed by weather or insects. A random selection of plots in the study area and the number of pellet groups in each plot is tallied and summed (Bower *et. al* 1990). An index of density (ID) of the number of pellet groups per unit area is then determined as:

$ID = n / A$

Where n is the sum of pellet groups counted over all plots and A is the total area sampled (i.e. the sum of the areas of all plots).

This method is effective in the habitats with dry weather and little or no dung beetle activity where pellet groups remain preserved between sampling periods.

After counting pallets, one must be assured that they will not be counted on successive sampling periods so they should be removed by the observer. Defecation rates for the species under the study are closely estimated if it is desired to convert pellet counts to number of animals.

2.1.7 Interviews with local residents

Interviews with local residents are valuable not only for the survey site selection but also in identifying the potential areas and a good source of primary data about the existing wildlife of the area. This method was very helpful in locating different mammal species in all the four study sites. However, despite the effectiveness of this method, minimal emphasis was placed on this source regarding the populations of different animals as it is assumed that the data regarding the population estimates could be biased.

2.1.8 Equipments and Field Kit

Equipments and field kits used for watching different mammals and assessing their populations in different study sites included:

1. Digital camera to record the photographic evidences of the mammals
2. Search lights for night vision of nocturnal mammals on 4x4 vehicles.
3. Measuring tape to record the size of foot prints and fecal droppings.
4. Binoculars (10x50) to observe the diurnal large mammals.
5. Geographical Positioning System (GPS) to record the coordinates.
6. Field guide books for assistance in quick identification of mammals.
7. Note book and pencils for recording field notes.
8. Satellite maps of the study sites.

2.2 Small Mammals

It is an effective way to survey mammals in active searching, particularly during the daytime. This method is equally applicable to both nocturnal and diurnal species. The study area was actively searched for potential and suitable microhabitats along the canal banks, open plains, bushy areas and agriculture fields. Active searching is very effective for inventory of Gerbilus, Meriones, Hysrix and Hemiechinus species. This method is most effective for those small mammals which cannot be trapped easily e.g. Hedgehog.

To investigate nocturnal species, night surveys were conducted in exposed areas of potential habitats on the ground. This methodology involved the use of a powerful 4orcH light, sticks, long boots, gloves etc.

2.2.1 Bait

A22mixture of different food grains mixed with fragrant seeds was used as bait for The attraction of The small mammals. Wheat and rice were used as food grains while peanut butter, coriander, oats and onion were used as fragrance. This bait was found highly successful in the study area due to the overall food shortage and fragrance. Freshly prepared bait was used on every trapping morning. Only small amount of bait was placed on the platform fitted on the rear side of the trap.

2.2.2 Traps and trapping procedure

Sherman traps were used for the present studies to collect the live specimens. Fifty traps were at a specific area on a line approximately 500 m long and traps were set approximately 10 m apart. Each trap was marked by a colorful ribbon to locate the traps easily. The traps were set in the afternoon and checked early in the morning. The specimens were transferred into polythene bags and were identified in the field and released. The specimens with some doubt were preserved in 10% formalin and were sent

to the laboratory and identified using identification keys. At least one specimen preserved for reference.

2.2.3 Data collection

The species of the trapped animal was noted as was the net weight, gender and other relevant information such as date, habitat, location, elevation and weather conditions.

2.3 Reptiles and amphibians

2.3.1 Survey method

The activities of amphibians and reptiles are highly seasonal and are influenced by the variation of weather even on a daily basis due to their exothermic and cryptic nature. It is more fruitful to survey them during their activity periods. Amphibians are usually most active just after dusk during their breeding season; many diurnal reptiles such as skinks and some lizards are active in mid-morning whereas nocturnal reptiles such as certain skinks and some lizards are active in mid-morning whereas nocturnal reptiles such as certain snakes and geckos would be active only at night.

Most amphibians and reptiles go into hibernation during winter. They would be under-estimated if surveys were carried out during this time. As such, it would be essential to survey herpto-fauna at appropriate timings in order to collect a representative baseline for assessment. Many reptiles such as snakes and lizards are timid, secretive, fast moving and cryptically colored. This renders survey of reptiles difficult. The reptiles therefore tend to be under represented in ecological surveys in general. More intensive surveys with appropriate survey methodologies would rectify such limitations.

There are standard methods for the studies of Amphibians and Reptiles (Foster and Gent, 1996; Hayek and Martin, 1997). All these techniques have been summarized in the EIAO Guidance Note, 2004. A brief summary is given below:

2.3.2 Active searching

An effective way to survey amphibians and reptiles is by active searching particularly during the day time. This method is equally applicable to both nocturnal and diurnal species. The study area was actively searched for potential breeding areas of amphibians (e.g. marshes, small water poles, water channels) and suitable microhabitats for both amphibians and reptiles (e.g. stones, pond bunds, crevices, leaf litter/debris, rotten log).

These places were deliberately uncovered to search for the eggs and tadpoles of amphibians and aquatic habitats or to reveal the presence of the amphibians and reptiles hiding under these covers. Active searching was carried out in all the locations with a focus on suitable microhabitats. In winter, most of the active searching was only possible

and limited to the pre-dusk time, as the low night temperatures hindered the activities of the herpetiles.

Searching for the nocturnal species of amphibians and reptiles was carried out in exposed areas of their potential habitats on ground, along the path or the pond/stream bank.

2.3.3 Trapping

'Pit – fall' trapping is one of the efficient methods of collecting amphibians and reptiles. Pitfalls however require regular monitoring, which is not possible in short term surveys. The most suitable location for such traps is the sandy habitat, which yields great success in trapping the animals. The drifts along which traps were placed/set, guided the animals to fall into the traps. Some leaf litter was put in the set trap to provide cover and moisture for any amphibians and reptiles, trapped inside. The traps were checked regularly within a reasonable time period, at least once per day, to avoid stress and death of trapped animals.

For the "Active Searching" and "Pit-fall trapping" requisite activities including Observations, Identification, Collection and Preservation were made as per plan of the studies.

2.3.4 Signs

Presence of signs like impression of body, tail or footprints, fecal pellets, tracks, dens or egg laying excavations were also some of the suitable methods to find out the existence, range and rough population of amphibian and reptilian fauna.

2.3.5 Collection

Hand picking (through bare hands or with the help of long forceps or snake clutch adopted for the present studies, has always been the most efficient way of collecting different species of amphibian and reptiles. However, for larger species like monitor lizard and rock agama, noose traps or other appropriate techniques were used. For handling snakes, especially poisonous ones, snake clutches/sticks were used. In addition to Hand picking, Scoop nets for shallow water and Cast nets in large water bodies were used for aquatic reptiles and amphibians. For frogs and toads, auditory detection of mating calls at the breeding sites is considered as an efficient method to find out the species; particularly the more vocal species and like toads.

2.3.6 Data Records

The species collected or observed during the survey were photographed with the digital camera and necessary field data were recorded. The coordinates and elevations were

recorded with the help of GPS. The voucher specimens collected were subsequently provided to the Zoological Survey Department for reference.

2.3.7 Preservation

The amphibian or reptile specimens were arranged in a tray in a position, which showed the features important for identification, e.g. mouth wedged open, one hind leg extended and fingers and toes spread. Preservatives such as 10% Formalin solution or 50-70% alcohol or methylated spirits solution in water was added to just cover the specimens, and the container was then covered and left until the specimens were set. In case of larger specimens, a slit was made in the belly and preservative was injected to preserve the internal organs. This step was omitted in case of frogs as they have thin and permeable water proof label was added to the jar, giving details of place, date and collector's name. A label was tied to the specimen written with permanent Indian ink or simple carbon pencil. The same details were stored with tadpole specimens, which don't need to be set, just dropped into preservative.

2.3.8 Identification of species

The specimens were identified with the help of most recent keys available in literature (Khan, 2003 and 2006)

2.3.9 Data Analysis

There are several numerical indices in use, which qualitatively describe different levels of diversity and evenness in samples collected from different localities or at different times from the same environment. One such commonly used diversity index is called "Shannon-weaver" index of diversity, which combines the number of species present and evenness into a single index. The formula is given as:

$D = - \Sigma$ pi in pi, where "i" stands for an index number for each species present in a sample, "pi" can be calculated through "ni/N" in which "ni" represents the number of individuals within a species divided by the total number of individuals "N" present in the entire sample and "ln" stands for natural log. In this way the proportion "pi" of each species in the sample times the natural log of that same value "ln pi" the values for each species and finally multiplied by -1. The value of "D" is always higher when species are equally abundant.

Similarly species evenness is calculated by the formula as:

$E = eD/s$, where "e" is the Shannon-weaver constant valuing 2.7, "D" is the value of Shannon-weaver index and "s" represents the number of total species in a sample. Species evenness, thus, separates the effect of different population sizes (number of individuals within species) from number of species (species diversity).

2.4 Birds

2.4.1Survey Method

The major habitat types in the study area available for birds were identified. The species and numbers of birds of each species found in each habitat type were recorded with particular emphasis on the key species. The data was also to be related to other components of the study area such as vegetation, water and soil etc. The field surveys covered both migratory and resident birds.

The most commonly used field method in bird surveying is the "Line Transects" method. It is based on recording birds continually along a predefined route within a predefined survey unit. It can be used in terrestrial, freshwater or marine ecosystems to survey individual species, or group of species. It is used to examine bird-habitat relationships and to derive relative and absolute measures of bird abundance.

Line transects are suitable for extensive, open and uniform habitats and for large and conspicuous species. Double counting of birds becomes a minor issue as the observer is continually on the move. Line transects are suited to situations where access is good and these are very useful for bird-habitat studies (Gregory *et al* 2004).

In the present studies, each sample area was traversed and examined by two observers separately. Birds were searched on each side of the strip for 150 m so that each study strip was 300 wide. Binoculars and telescopes were used to identify bird species and count or assess bird numbers.

2.4.2 Evaluation of water bird numbers

To evaluate the numbers of water-birds utilizing a site, observation is made from a stationary point or by moving through the area using binoculars and telescopes. Below is a summary of when to count accurately or estimate the numbers of water-birds present:

a) Counting individual birds within an area

- Small number of birds present *i.e.*<1,000
- Limited inter – or intra – site movement by water-birds *i.e.* the birds are stationary at a roost site.
- No on-site disturbance *i.e.* People, birds of prey, which may force birds to fly frequently within the site.
- The birds are well spaced out *i.e.* foraging in an open area.

b) Estimating the numbers of birds within an area

- Large numbers of birds present *i.e.*>1,000
- Birds continually in flight i.e. moving along the coast to a roost site in large flocks.

- A lot of disturbance forcing birds to be unsettled and continually take flight, making prolonged observation on the ground difficult.
- A closely packed flock of birds, where due to 'tightness' of the flock counting individual birds is difficult *i.e.* at a large roost.
- Due to poor light conditions *i.e.* viewing into the sun or over a great distance, identification of particular species is not possible.

2.4.3 Methods of accurate count

- Close viewing of individuals with binoculars or a telescope. Counting 1,2,3,4,5,6,…….etc.
- Distant viewing of an evenly distributed flock. Counting 1,2,3,4,5,6……etc.
- Visually dividing birds into small groups and counting each group individually, i.e. when there is an uneven distribution of numbers. Totals for each group are then added to form the final total.
- Counting flocks in multiples i.e. 3,6,9,12,15……..etc. or 2,4,6,8,10…..etc. This method can be used for either evenly or unevenly distribution of water-birds. (Howes, J. and Backwell, D. 1989).

Since all the birds would not be resident in the area, they may be either, winter visitors, passage migrants, summer (breeding) visitors or resident etc. Hence, an attempt will be made to cover all the recognized breeding and wintering habitat types in the area with at least one survey carried out over the summer and one in winter season for each habitat type.

2.5 Physio-chemical Properties of Water

The samples were collected on 6th February 2011 in clean acid rinsed bottles for the general water quality parameters such as pH, Chloride, Conductivity, Turbidity, Total Hardness, Total Alkanity, Cr (Hexa), Lead, Zn, COD, Iron and As.

The COD water samples were collected in separate coloured water bottles and kept in ice box for preservation. All samples were properly sealed under specific codes/labels and dispatched to the GEL Laboratory the day after the collection with proper custody protocol.

The sampling strategy was designed according to the site conditions and in consultation with the WWF team. Water samples were drawn considering full depth of standing water or flowing water.

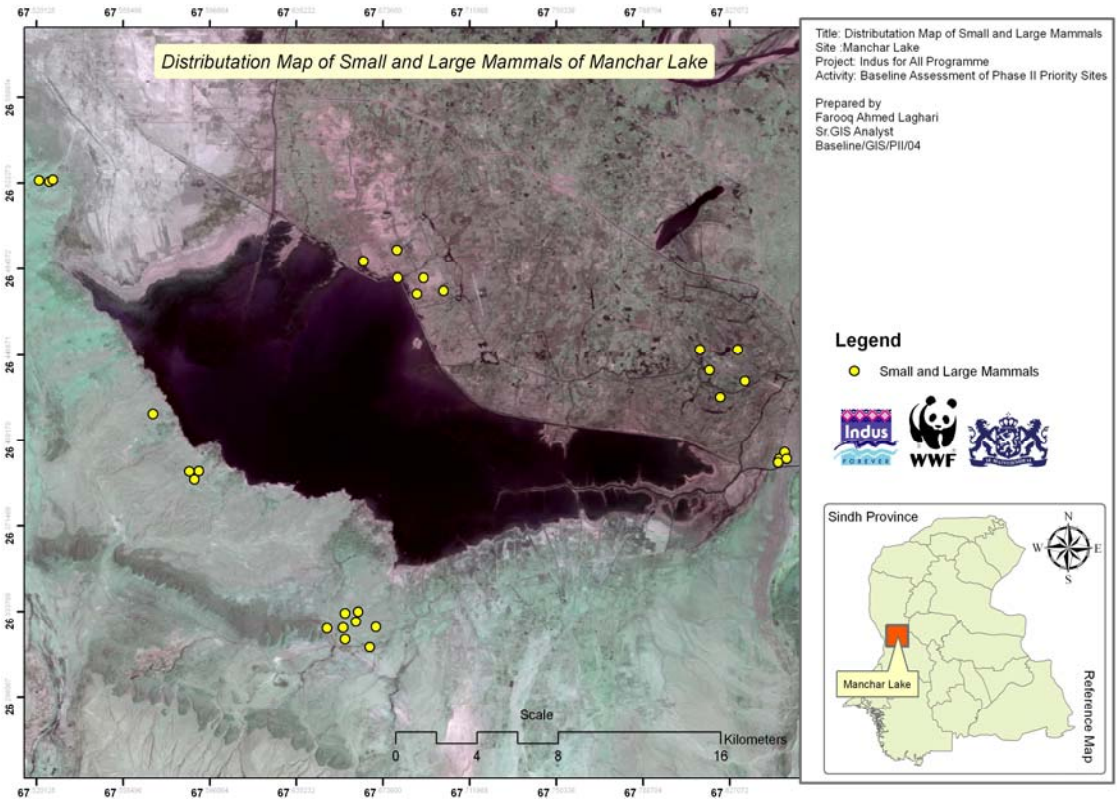
CHAPTER 3 – RESULTS AND DISCUSSION

3.1 Large Mammals

3.1.1 Sampling locations

Almost all the potential sites around Manchhar Lake were visited to locate the existing large mammals; GPS coordinates at relevant locations were noted. Different sampling sites around Manchhar during surveys are given in Maps 2 and 3. GPS coordinates taken during surveys are given in annex document.

Map 2 – Sampling sites of mammals at Manchhar



3.1.2 Species identified

During surveys, seven animals of 5 different species, belonging to other Carnivora were observed in the study area, as given in Table 1 below:

Table 1 – Mammals recorded from Manchhar Lake area

S. No	Common Name	Scientific Name	Order	Animals Observed
1	Asiatic jackal	*Canis aureus*	Carnivora	2
2	Red Fox	*Vulpes vulpes*	Carnivora	1
3	Jungle cat	*Felis chaus*	Carnivora	1
4	Small Indian mongoose	*Herpestes javanicus*	Carnivora	2
5	Grey mongoose	*Herpestes edwardsi*	Carnivora	1

3.1.1 Observation Records

The five recorded species of large mammals were observed directly as well as on the basis of indirect evidences like tracks/foot prints and interviews with the local people. Observation records of different mammalian species at Manchhar Lake are given in the Table 2 below.

Table 2 – Observation records of different mammal species from Manchhar Lake

S. No	Species	Direct Observation	Indirect Observation		
			Foot prints	Fecal material	Interviews with locals
1	Asiatic jackal	✓	-	-	✓
2	Red Fox	✓	-	-	✓
3	Jungle cat	✓	-	-	✓
4	Small Indian mongoose	✓	-	-	✓
5	Grey mongoose	✓	-	-	✓

3.1.1 Conservation Status of Recorded Mammals

Out of the 5 recorded species, one is Vulnerable (VU) and four are Least Concern (LC) according to the IUCN Red List 2011. Two species are listed in Appendix II of CITES, as given in Table 3. Appendix II lists the species that are not threatened at present but may become so unless trade is closely controlled. Jungle cat is protected as per Sindh Wildlife Protection Ordinance 1972.

Table 3 – Conservation status of mammals found at Manchhar Lake

S. No	Mammalian Species Recorded	IUCN Red List 2011	Sindh Wildlife Protection Ordinance 1972	CITES Category 2011
1	Asiatic jackal	LC	-	-

2	Red Fox	LC	-	-
3	Jungle cat	LC	P	Appendix II
4	Small Indian mongoose	VU	-	Appendix II
5	Grey mongoose	LC	-	-
Legend: VU = Vulnerable, LC = Least Concern, P = Protected				

3.1.5 Threats and recommendations

3.1.5.1 Threats

- Effect of flood: Some species of mammals have been affected by the floods and their overall population has decreased;
- There is no significant threat to the existing terrestrial species of large mammals, except that the wilderness is being steadily reduced by agriculture and other land use practices;
- The locals are not aware of the importance of wildlife and they take it only as creatures not valued as a natural resource.

3.1.5.2 Recommendations

- Education and awareness programmes regarding conservation of mammals be launched to minimize the anthropogenic threats to the species and their habitat;
- A management plan for Manchhar Lake may be developed and implemented;
- Manchhar Lake Development Authority be established with representation from local communities, NGOs and relevant government departments;
- Signboards may be installed at the entrance point to the Manchhar Lake with information on mammals for public awareness.

3.2 Small Mammals

3.2.1 Sample locations

The Map shown below indicates sampling locations of small mammal trapping at Manchhar Lake.

Map 5 – Details of trapping locations for mammals at Manchhar Lake

3.2.1 Species account

Eight species were observed. The species belonged to3 orders (Rodentia, Lagomorpha and Insectivora) and 5 families. Table 4 gives an account of the species recorded at Manchar along with their status, feeding habits and activity habits.

Table 4 – Species recorded at Manchhar Lake along with conservation status, feeding and activity habits

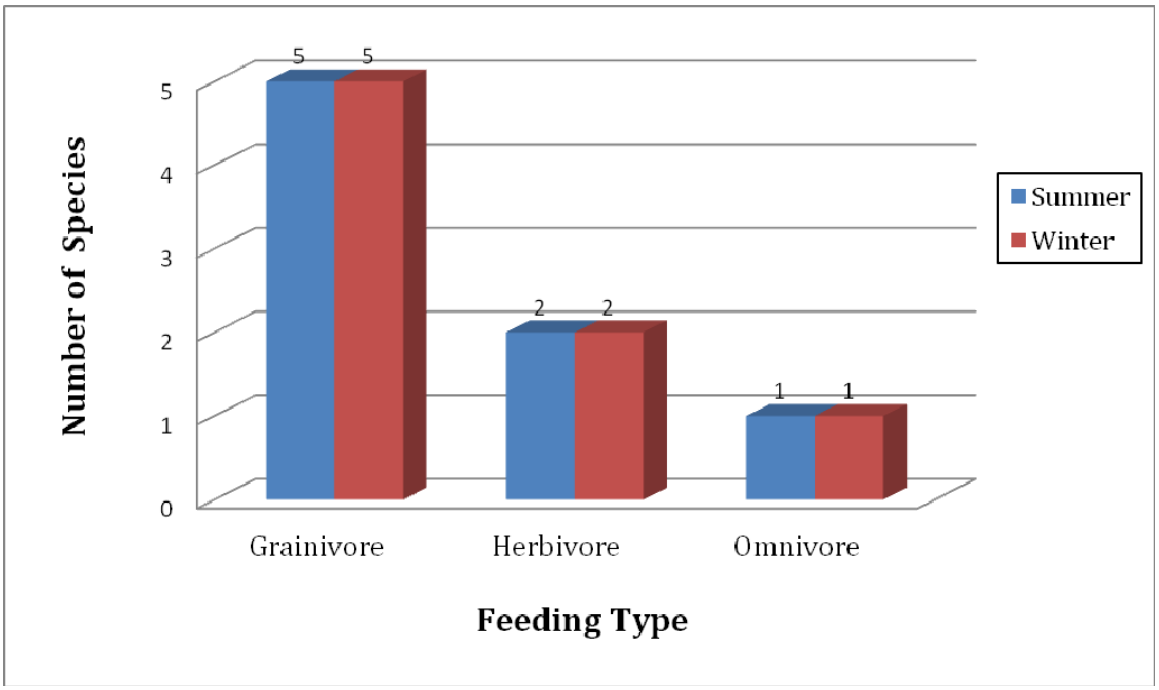
S. No	Scientific Name	English Name	Feeding Habit	Behavior	Status	Winter	Summer
Order: Rodentia							
Family: Sciuridae							
1	*Funambulus pennanti*	Five-striped Palm Squirrel	GRN	DR	C	10	8
Family: Muridae							
2	*Gerbilus nanus*	Balochistan Gerbil	GRN	NC	C	6	7
3	*Mus musculus*	Common House Mouse	GRN	NC	C	6	6
4	*Tatera indica*	Indian Gerbil	GRN	NC	C	8	10
5	*Meriones hurrianae*	IndianDesert Jird	GRN	DR	Sc	10	8
Family: Hystricidae							
6	*Hystrix indica*	Indian crested porcupine	HRB	NC	Sc	1	2
Order Lagomorpha							
Family Leporidae							
7	*Lepus nigricollis*	Desert hare	HRB	NC	Sc	2	6
Order Insectivora							
Family Erinaceidae							
8	*Hemiechinus collaris*	Long-eared Hedgehog	OMN	NC	R	1	3

Legend: GRN=Grainivore, OMN=Omnivore, HRB=Herbivore, NC=Nocturnal, DR=Diurnal, C=Common, R=Rare, Sc = Scarce

3.2.3 Feeding habits

Most of the small mammal species recorded from Manchhar are granivores (five) followed by herbivores (two) and Omnivores (one). Figure 2 gives a graphical portrayal of the number of species by feeding habits.

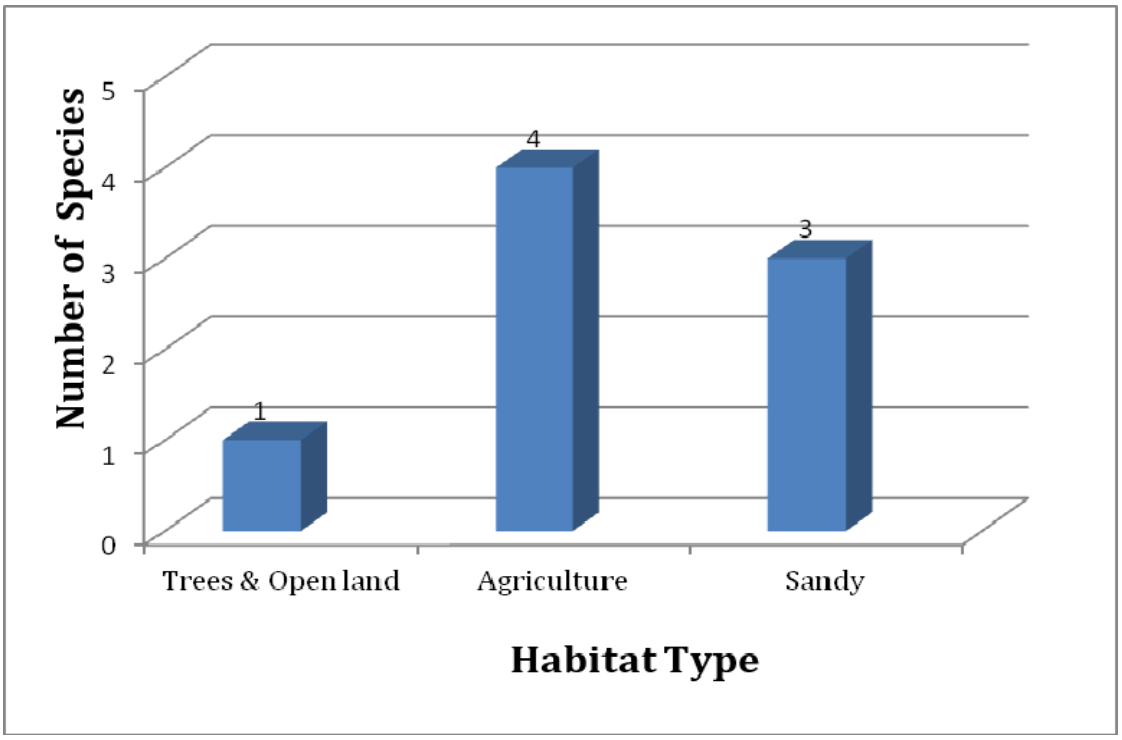
Figure 1 – Distribution of small mammal species recorded at Manchhar Lake by feeding types



3.2.4 Habitat and occurrence

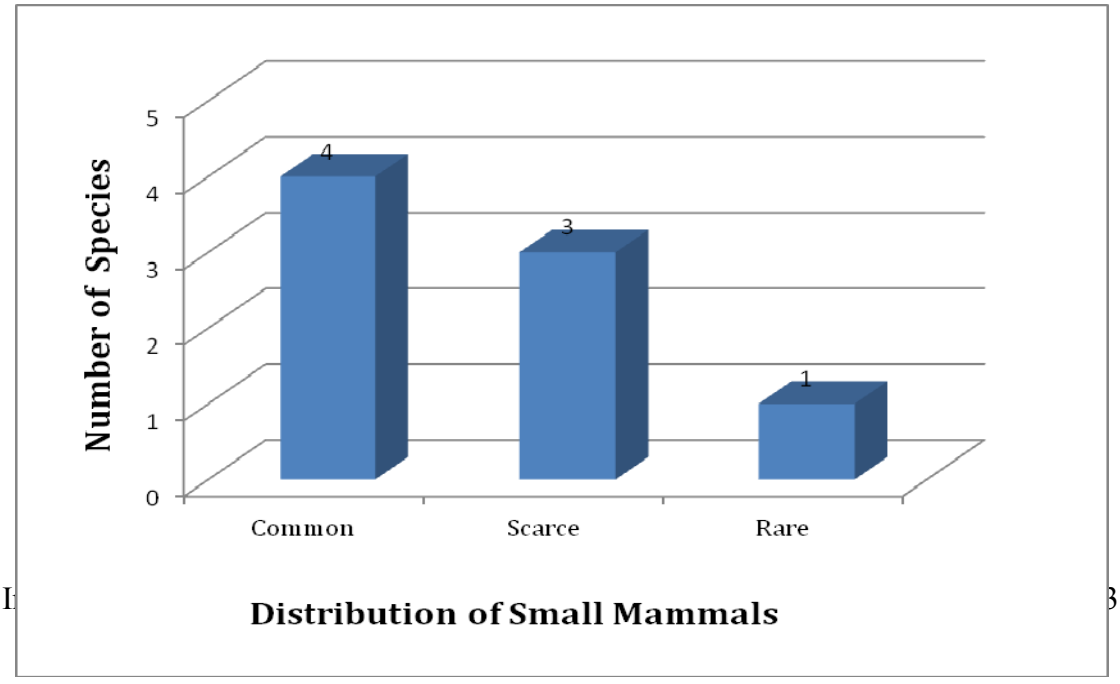
Manchhar lake area contains diverse habitats such as wetland area, agricultural land which provide shelter for a variety of small mammals. This is reflected by the number of species recorded both in winter and summer. Family Muridae was the most wide spread family. The majority of species were recorded from agricultural land (as shown in Figure 3) followed by open land habitat and around human habitations.

Figure 2 – Number of species recorded from habitat types



Out of the total species recorded from Manchhar, four are common, three scarce and one rare. These figures do not reflect the status of each species at site level which requires longer term studies.

Figure 3 – Small mammal status by the species and season at Manchhar Lake



3.2.5 Threats and recommendations

3.2.5.1 Threats

- Due to human actions, species and ecosystem is affected;
- Mining activities in the area are a threat to the habitat and species:
- The recent floods have also affected and due to inundation in the area, the holes and burrows of animals have been destroyed.

3.2.5.2 Recommendations

- Efforts may be made to minimize the disturbances through mining and other human actions in order to safeguard species and habitat;
- Environmental education and awareness programmes on reptiles may be initiated to aware people of their importance.

3.3 Reptiles and amphibians

3.3.1 Sample locations

Map 6 shows the details of trapping locations of reptiles and amphibians from Manchhar. Details of sampling points can be found in the annexure document.

Map 6 –Sampling/trapping locations for reptiles and amphibians at Manchhar

3.3.2 Summary

Manchar Lake is set in somewhat multiple habitats. The NE is flat plain and predominantly agronomical area while the SW consists of hilly area and rangeland. Several of the villages were surveyed in December 2010 for the presence of reptiles and amphibians including Goth Meerani, Ali Bakhsh Panhawar, Gul Mohd. Shani, Dost Mohd. Shani, Bandhni, BJP Camp and Channi. Both diurnal and nocturnal surveys were conducted for collection of the data. The winter studies resulted in the recording of 17 species of reptiles belonging to 2 orders, 9 families and 13 genera. In summer, only one additional species, Red-throat Ground Agama *(Trapelus rubigularis),* was recorded. According to feeding habits of reptiles, there were 10 insectivorous and 8 carnivorous species. As regards the status of different species, 8 species were rare, 7 common and 2 species were abundant.

Among Amphibians, two species were recorded belonging to the families Bufonidae and Ranidae. The Indus Toad was abundant while the Skittering Frog was recorded as Common. Both the species are insectivorous and mainly nocturnal.

Table 5: Reptilian and Amphibian Species recorded at Manchhar

	English Name	Scientific Name	Status	Activity Pattern	Feeding Habits	Summer	Winter
Reptiles							
Order Chelonia							
Family Trionychidae							
1	Indian Flap-shell turtle	*Lissemys punctata andersoni*	R	Diurnal	CAR	1	1
Order Sauria							
Family Agamidae							
2	Afghan Ground Agama	*Trapelus megalonyx*	R	Diurnal	INS	4	1
3	Red-throat Ground Agama	*Trapelus rubigulais*	C	Diurnal	INS	12	-
4	Brilliant Agama	*Trapelus agilis pakistanensis*	C	Diurnal	INS	6	3
5	IndianGarden Lizard	*Calotes v. versicolor*	C	Diurnal	INS	8	4
6	Yellow headed rock agama	*Laduakia fusca*	C	Diurnal	INS	4	1
Family Gekkonidae							
7	Yellow-bellied House Gecko	*Hemidactylus flaviviridis*	A	Nocturnal	INS	5	1
8	Spotted Indian House Gecko	*Hemidactylus brookii*	C	Nocturnal	INS	6	2
9	Keeled rock gecko	*Cyrtopodion scaber*	C	Nocturnal	INS	8	4
Family Lacertidae							
10	Indian fringe toed sandy lizard	*Acanthodactylus cantoris*	R	Diurnal	INS	6	4
11	Punjab snake-eyed Lacerta	*Ophisops jerdonii*	C	Diurnal	INS	4	1
Family Varanidae							
12	Bengal Monitor	*Varanus bengalensis*	A	Non-specific (mostly diurnal)	CAR	6	2
13	Indo-PakDesert Monitor	*Varanus groseus koniecznyi*	R	Non-specific (mostly	CAR	2	1

				diurnal)			
Family Scincidae							
14	Three fingered sand fish	*Ophiomorus rathmai*	R	Nocturnal	INS	10	3
Order Squamata							
Family Boidae							
15	Indian Sand boa	*Eryx johnii*	R	Nocturnal	CAR	1	1
Family Colubridae							
16	Indus valley wolf snake	*Lycodon s. striatus*	R	Nocturnal	CAR	1	1
17	Cliff racer	*Platyceps r. rhodorachis*	C	Diurnal	CAR	2	1
Family Elapidae							
18	Black Cobra	*Naja naja naja*	R	Non-specific (mostly diurnal)	CAR	4	1
Amphibians							
Order Anura							
Family Bufonidae							
19	Marbled Toad	*Bufo stomaticus*	A	Non-specific (mostly diurnal)	INS	15	10
Family Ranidae							
20	Skittering Frog	*Euphlyctis c. cyanophlyctis*	C	Non-specific (mostly diurnal)	INS	10	8

Legend

3.3.3 Species richness

Species Richness (s) is a relative term that refers to the number of species in a community, and is directly associated with measuring the diversity of species in a given area. A related term, evenness (E), is another dimension of diversity that defines the number of individuals from each species in the same area. Together, these terms have been used to describe species diversity patterns on Earth.

There are several hypotheses that have been proposed to explain species diversity patterns. Many of these hypotheses are based upon the idea that species are more diverse near the equator than near the poles. In other words, there is a recognized latitudinal gradient of species diversity on Earth. The hypotheses that support this latitudinal gradient can be divided into two groups: abiotic and biotic. The biotic hypotheses are those that explain species diversity patterns with relation to living organisms. The abiotic

hypotheses, on the other hand, explain species diversity patterns with relation to non-living chemical and physical environmental factors.

Table 6 gives four indexes of richness starting with the number of species. Evenness and two biodiversity indexes are also given in the table, namely Shannon's and Margalef Indexes.

Shannon's Index:

The Shannon-Weaver diversity index looks at how a species is distributed in the an ecosystem. To perform this calculation, you need to sample a population by taking a look at a given area, counting the different species in the population and assessing their abundance there. The Shannon-Weaver diversity index is also known as the Shannon index or Shannon-Wiener index. This is an important measurement for biodiversity.

Let's use our sample data (20 species, 115 total individuals) and calculate D i.e. Shannon Index for summer:

Species	Afghan Ground Agama	Red-throat Ground Agama	Bengal monitor	Indian Flap-shell turtle	Yellow-bellied House Gecko	Brilliant Agama	Black Cobra	Indo-Pak Desert Monitor	Marbled Toad	Indian fringe toed sandy lizard
n_i (population size)	4	12	6	1	5	6	4	2	15	6
p_i	0.035	0.104	0.052	0.009	0.043	0.052	0.035	0.017	0.130	0.052
ln p_i	-3.35	-2.26	-2.96	-4.71	-3.15	-2.96	-3.35	-4.07	-2.04	-2.96
p_i x ln p_i	-0.12	-0.23	-0.15	-0.04	-0.13	-0.15	-0.12	-0.07	-0.26	-0.15

Punjab snake-eyed Lacerta	Skittering Frog	Cliff Racer	Indus Valley Wolf Snake	Keeled rock gecko	Spotted Indian House Gecko	Indian Sand Boa	Indian Garden Lizard	Yellow headed rock agama	Three fingered sand fish	**Total = N**
4	10	2	1	8	6	1	8	4	10	115
0.035	0.087	0.017	0.009	0.070	0.052	0.009	0.070	0.035	0.087	

-3.35	-2.44	-4.07	-4.71	-2.66	-2.96	-4.71	-2.66	-3.35	-2.44	
-0.12	-0.21	-0.07	-0.04	-0.19	-0.15	-0.04	-0.19	-0.12	-0.21	**-2.76 = Σ**

S = 20 species
N = 115 individuals
$D = -\Sigma p_i \ln p_i = -1 \times -2.76 = 2.76$

Remember: The value of **D** is highest when species are equally abundant.

Let's use our sample data (19 species, 50 total individuals) and calculate D i.e. Shannon Index for winter:

Species	Afghan Ground Agama	Red-throat Ground Agama	Bengal monitor	Indian Flap-shell turtle	Yellow-bellied House Gecko	Brilliant Agama	Black Cobra	Indo-Pak Desert Monitor	Marbled Toad	Indian fringe toed sandy lizard
n_i (population size)	1	-	2	1	1	3	1	1	10	4
p_i	0.02	-	0.04	0.02	0.02	0.06	0.02	0.02	0.2	0.08
$\ln p_i$	-3.91	-	-3.21	-3.91	-3.91	-2.81	-3.91	-3.91	-1.61	-2.52
$p_i \times \ln p_i$	-0.08	-	-0.19	-0.08	-0.08	-0.17	-0.08	-0.08	-0.32	-0.20

Punjab snake-eyed Lacerta	Skittering Frog	Cliff Racer	Indus Valley Wolf Snake	Keeled rock gecko	Spotted Indian House Gecko	Indian Sand Boa	Indian Garden Lizard	Yellow headed rock agama	Three fingered sand fish	**Total = N**
1	8	1	1	4	2	1	4	1	3	50
0.02	0.16	0.02	0.02	0.08	0.04	0.02	0.08	0.02	0.06	
-3.91	-1.83	-3.91	-3.91	-2.52	-3.21	-3.91	-2.52	-3.91	-2.81	

-0.08	-0.29	-0.08	-0.08	-0.20	-0.19	-0.08	-0.20	-0.08	-0.17	**-2.73 = Σ**

S = 19 species
N = 50 individuals
D = $-\Sigma p_i \ln p_i$ =-1 x -2.73 = 2.73

Remember: The value of **D** is highest when species are equally abundant.

Species Evenness The diversity of species in a particular area depends not only the number of species found, but also in their numbers. Ecologists call the number of species in an area its richness, and the relative abundance of species its evenness. They are both measures of diversity.

Divide Shannon's diversity index H by natural logarithm of species richness ln(S) to calculate the species evenness. Note that species evenness ranges from zero to one, with zero signifying no evenness and one, a complete evenness.

E = D/ log (S)

Therefore for summer it is: E = D/ Log(S)= 2.76/ log(20) = 0.92

For winter it is: E = D/ Log(S)= 2.73/ log(19) = 0.93

Margelef Index:
It is a measure of species diversity. It is calculated from the total number of species presentand the abundance or total number of individuals. The higher the index the greater the diversity.

Da = (S-1) / log to base e N
Where Da = Margalef Index
S = No. of Species
N = Total No. of Individuals
e = 2.7 (constant),

Therefore for Summer it will be: Da = (S-1) / log to base e N
Da = 20-1 / log (2.7 * 115)
= 19 / log (310.5) = 19 / 5.74
= 3.31

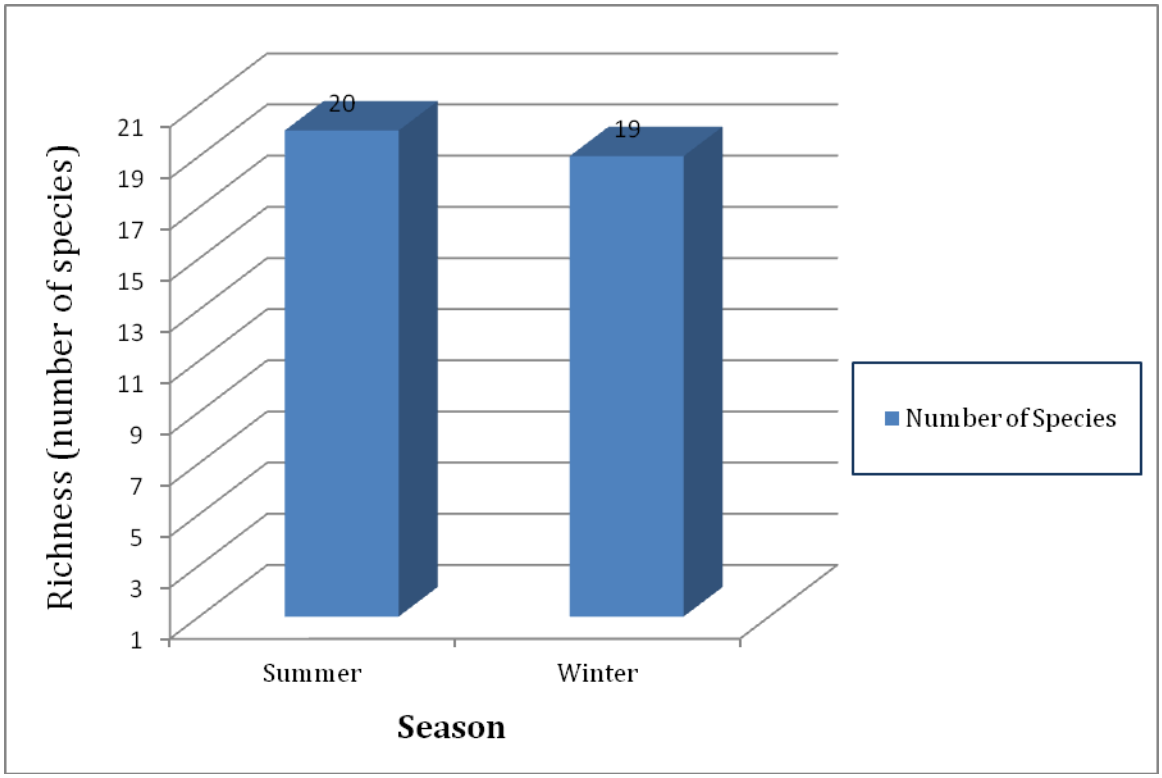
For winter it will be: Da = (S-1) / log to base e N
Da = 19-1 / log (2.7 * 50)
= 18 / log(135) = 18 / 4.9
= 2.51

Table 6 – Diversity indices for reptiles and amphibians recorded from Manchhar

S. No.	Index type	Summer	Winter
1	Richness (number of species)	20	19
2	Evenness	0.92	0.92
3	Shannon index	2.76	2.73
4	Margalef index	3.31	2.51

Evenness of the species in both the seasons i.e. in summer and in winter is almost same, however summer figure in Margalef index is little bit higher; it is because more reptile species come out during summer while in winters they hibernate.

Figure 4 – Number of reptile and amphibian species recorded during summer and winter from Manchhar Lake



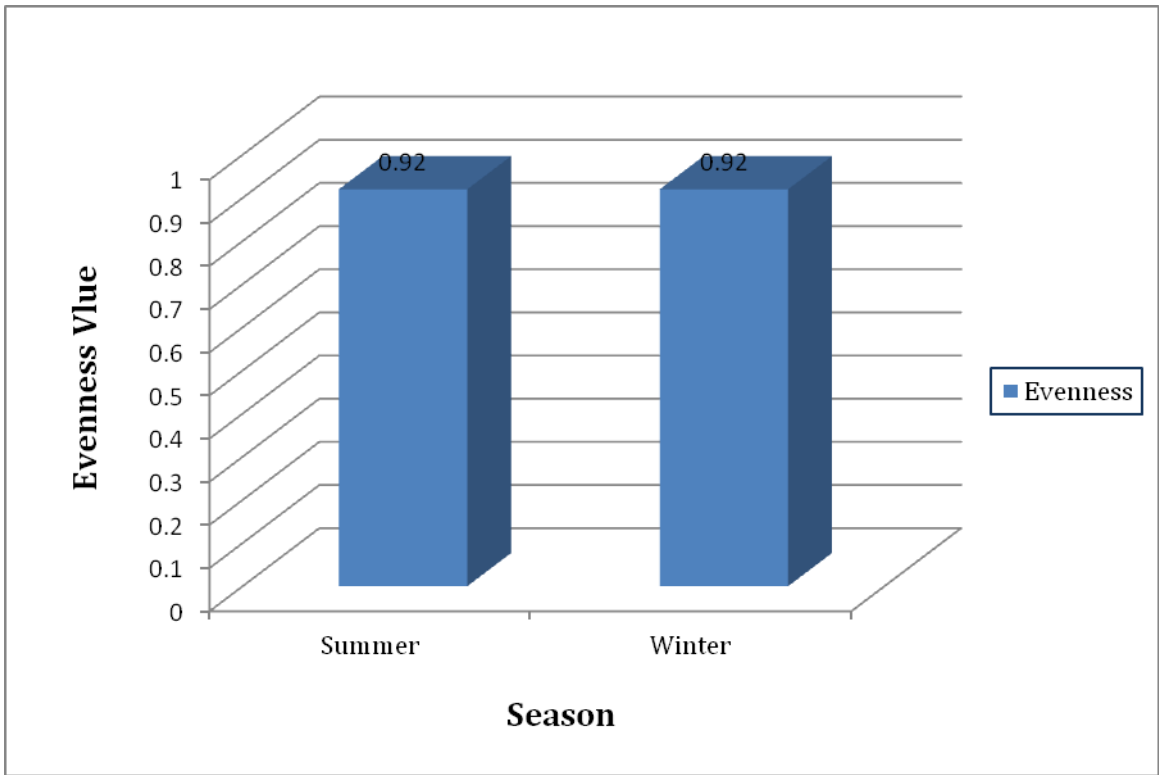
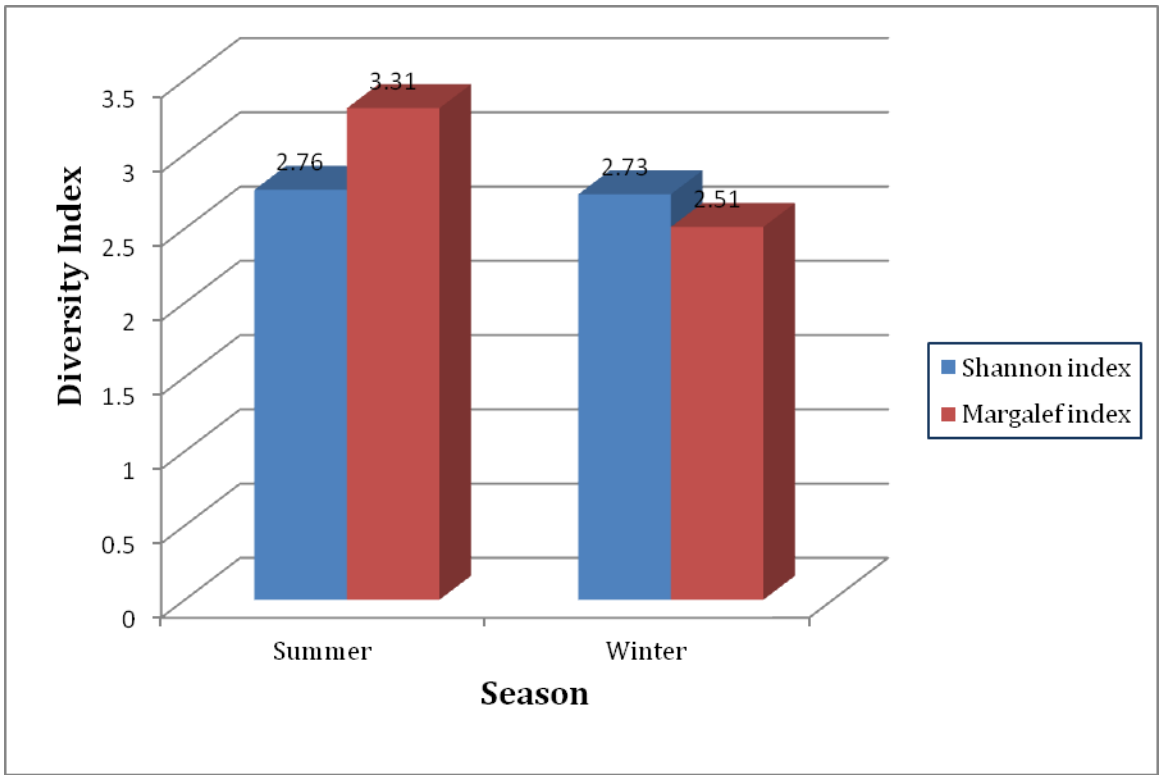


Figure 5 – Shannon and Margalef indexes for summer and winter at Manchhar Lake



Discussion

More species of reptiles and amphibians were observed in summer than in winter at Manchhar Lake. The reptiles and amphibians usually hibernate in winter so it is not an unusual phenomenon. However, there was only one additional species recorded in summer, otherwise the same species were recorded in both seasons.

3.3.4 Threats and recommendations

3.3.4.1 Threats

- Pollution on account of pesticides and drain water is a serious threat to the aquatic biodiversity including the freshwater turtles.
- Lizards and Snakes are considered as undesired animals and hence these are usually killed by the locals.
- Roadside kills of Monitor Lizards are quite common in the area.

3.3.4.2 Recommendations

- The local communities should be educated about the importance of reptiles and amphibians of the area through workshops, trainings and through print media.
- Regular surveys to determine the status of freshwater turtles need to be undertaken. The possibilities for their captive breeding may also be explored, as it may become one of the alternate sources of livelihood for the local communities.

- Alternate means for the livelihood of the local communities may be provided through micro financing for aquaculture, apiculture and cottage industries.
- Signboards may be installed on the roads indicating the important habitats of reptiles and amphibians along with instructions and appeals for protecting the wildlife of the area.

3.4 Birds

3.4.1 Sampling locations

The Map given below shows the observation points of bird surveys at Manchhar Lake over summer and winter.

Map 6 – Sampling sites of birds at Manchhar during winter

The locations visited during the surveys were agriculture fields, fruit orchards, small forest areas having Mesquite, *Salvadora, Capparis, Typha* and *Phragmites spp.*, mangrove forest, inland coastal belt and creek areas.

3.4.2 Summary

Manchhar lake is very important area for waterbirds and fishes. It is also a very important wetland for its socio-economic values. It has been an important site for supporting large concentrations of waterbirds particularly the anatids and the coots. Previously, 26,000 waterbirds were recorded during mid-winter counts in 1988 and 45,306 in 1991.White Pelican, Little Grebe, Redcrested Pochard, Tufted Duck, Cotton Teal, Common Teal, Gadwall, Shoveller, Mallard, White-eyed Pochard, Great crested Grebe, Large Cormorant and Coot have been recorded from this wetland. As many as 31,852 waterbirds have been recorded in the Asian Waterbird Census 2000, 9491 in 2001, 8260 in 2003 and only 1183 in 2011.

The number of waterbirds has drastically declined during recent years because the lake lost its significance as an important waterbird area due to heavy pollution impacts on its water quality during the preceding years. The influx of heavy floods during August 2010 brought some very positive changes to the wetland by improving the water quality at least for the time being.

A total of 75 species belonging to 11 orders and 33families were recorded from the area.

3.4.3 Species account

3.4.3.1 Winter and Summer

Table 7 shows the birds species observed at Manchhar Lake during winter and summer.

Table 7 – List of bird species recorded from Manchhar Lake

	English name	Scientific name	Status	Occurrence	Count	
					Summer	Winter
Order Podicepidiformes						
Family Podicepididae						
1	Little Grebe	*Tachybaptus ruficollis*	R	Common	40	36
Order Pelecaniformes						
Pelicanidae						
2.	White Pelican	*Pelecanus onocrotalus*	WV	Scarce	-	8
Family Phalacrocoracidae						
3	Large Cormorant	*Phalacrocorax carbo*	WV	Common	-	220
4	Little Cormorant	*Phalacrocorax niger*	R	Common	40	180
Order Ciconiiformes						
Family Ardeidae						
5	Indian Pond Heron	*Ardeola grayii*	R	Common	50	47
6	Large Egret	*Egretta alba*	WV	Scarce	-	14
7	Little Egret	*Egretta garzetta*	R	Common	60	25
8	Intermediate Egret	*Egretta intermedia*	R	Scarce	-	10
9	Indian Reef Heron	*Egretta gularis*	R	Common	20	55
10	Cattle Egret	*Bubulcus ibis*	R	Scarce	60	10
Family Threskiornithidae						
11	Spoonbill	*Platalea leucorodia*	WV	Rare	-	4
Order Anseriformes						
Family Anatidae						
12	Common Shelduck	*Tadorna tadorna*	WV	Scarce	-	12
13	Common Teal	*Anas crecca*	WV	Common	-	148
14	Shoveller	*Anas clypeata*	WV	Common	-	36
Order Falcaniformes						
Family Accipitridae						
15	Common Kite	*Milvus migrans*	R	Common	30	70
16	Blackwinged	*Elanus*	R	Rare	4	2

	Kite	*caeruleus*				
17	Shikra	*Accipiter badius*	R	Rare	2	1
18	Long legged Buzzard	*Buteo rufinus*	WV	Rare	-	2
19	Marsh Harrier	*Circus aeruginosus*	WV	Scarce	-	13
Family Falconidae						
20	Kestrel	*Falco tinnunculus*	WV	Scarce	-	6
Order Galliformes						
Family Phasianidae						
21	Grey Partridge	*Francolinus pondicerianus*	R	Common	30	56
Order Gruiformes						
Family Rallidae						
22	Coot	*Fulica atra*	WV	Common	-	160
23	Indian Moorhen	*Gallinula chloropus*	R	Common	10	13
Order Charadriiformes						
Family Charadriidae						
24	White-tailed Plover	*Vanellus leucurus*	WV	Scarce	-	8
25	Red wattled Lapwing	*Vanellus indicus*	R	Common	40	15
26	Yellow wattled Lapwing	*Vanellus malabaricus*	SBV	Rare	4	2
27	Little ringed Plover	*Charadrius dubius*	WV	Scarce	-	8
28	Kentish Plover	*Charadrius alexandrinus*	WV	Common	-	33
Family Scolopacidae						
29	Eurasian Curlew	*Numenius arquata*	WV	Scarce	-	13
30	Common Redshank	*Tringa totanus*	WV	Common	-	26
31	Common Sandpiper	*Tringa hypoleucos*	WV	Common	-	32
32	Little Stint	*Calidris minutus*	WV	Common	-	450
33	Ruff	*Philomachus pugnax*	WV	Common	-	45
Family Recurvirostridae						
34	Black winged Stilt	*Himantopus himantopus*	R	Common	300	220

Family Laridae						
35	Heuglin's Gull	*Larus heuglini*	WV	Common	16	50
36	Brownheaded Gull	*Larus brunnicephalus*	WV	Scarce	-	9
37	Black headed Gull	*Larus ridibundus*	WV	Common	-	670
38	Slenderbilled Gull	*Larus genei*	WV	Common	-	49
39	Caspian Tern	*Hydroprogne caspia*	YRV	Common	25	17
40	River Tern	*Sterna aurantia*	R	Common	30	45
41	Little Tern	*Sterna albifrons*	WV/R	Common	150	55
Order Columbiformes						
Family Pteroclididae						
42	Chestnut-bellied or Indian Sandgrouse	*Pterocles exustus*	R	Scarce	4	13
Family Columbidae						
43	Blue Rock Pigeon	*Columba livia*	R	Common	40	29
44	Ring Dove	*Streptopelia decaocto*	R	Common	300	275
45	Little Brown Dove	*Streptopelia senegalensis*	R	Common	150	100
Order Coraciiformes						
Family Alcedinidae						
46	Pied Kingfisher	*Ceryle rudis*	R	Common	20	25
47	Common Kingfisher	*Alcedo atthis*	R	Scarce	-	7
48	White breasted Kingfisher	*Halcyon smyrnensis*	R	Common	8	19
Family Meropidae						
49	Green Bee eater	*Merops orientalis*	R	Common	30	16
Family Coraciidae						
50	Indian Roller	*Coracias benghalensis*	R	Scarce	10	13
Family Upupidae						
51	Common Hoopoe	*Upupa epops*	WV	Rare	2	4
Order Passeriformes						
Family Alaudidae						

52	Desert Lark	*Ammomanes deserti*	WV	Common	-	32
53	Crested Lark	*Galerida cristata*	R	Common	40	42
Family Hirundinidae						
54	Pale or Sand Martin	*Riparia diluta*	WV	Common	-	19
55	Common Swallow	*Hirundo rustica*	WV	Common	-	39
Family Laniidae						
56	Rufous bellied or Isabelline Shrike	*Lanius isabellinus*	WV	Rare	-	4
57	Southern Grey Shrike	*Lanius meridionalis*	WV	Scarce	-	12
Family Dicruridae						
58	Black Drongo	*Dicrurus adsimilis*	R	Common	30	40
Family Sturnidae						
59	Rosy Pastor	*Sturnus roseus*	PM	Common	200	56
60	Bank Myna	*Acridotheres ginginianus*	R	Common	30	19
61	Indian Myna	*Acridotheres tristis*	R	Common	40	45
62	Common Starling	*Sturnus vulgaris*	R	Scarce	6	8
Family Corvidae						
63	House Crow	*Corvus splendens*	R	Common	50	27
Family Pycnonotidae						
64	White cheeked Bulbul	*Pycnonotus leucogenys*	R	Common	40	20
Family Timaliidae						
65	Common Babbler	*Turdoides caudatus*	R	Common	10	20
Family Sylviidae						
66	Rufous vented Prinia	*Prinia burnesii*	R	Rare	-	4
67	Common Chiffchaff	*Phylloscopus collybita*	WV	Scarce	-	10
Family Turdidae						
68	Black Redstart	*Phoenicurus ochruros*	WV	Rare	-	4
69	Pied Bushchat	*Saxicola caprata*	R	Common	12	29

70	Desert Wheatear	*Oenanthe deserti*	WV	Scarce	-	9
71	Hume's Wheatear	*Oenanthe alboniger*	R	Scarce	15	11
Family Motacillidae						
72	White Wagtail	*Motacilla alba*	WV	Common	-	32
73	Yellow Wagtail	*Motacilla flava*	PM	Common	-	35
Family Passeridae						
74	House Sparrow	*Passer domesticus*	R	Common	100	80
Family Emberizidae						
75	House Bunting	*Emberiza striolata*	R	Rare	2	4
TOTAL					**2,050**	**3,924**

[**Legend:** R = Resident, WV = Winter visitor, SV = Summer visitor, PM = Passage Migrant]

3.4.4 Summer and winter account

The results show that the number of species found in winter was greater than in the summer. A total of 75 species belonging to 11 orders and 33 families were recorded from the area. All the recorded 75 species were sighted in winter i.e. 100% of the total species whereas 39 species belonging to 10 orders and 26 families were recorded in summer which is about 52% of the total species. The total numbers counted in winter was 3,924 whereas in summer the figure is 2,050 only. The major reason for recording more species in winter and counting more birds could be the presence of migratory birds in the winter. In winter, there were 38 species of resident birds, 33 winter visitors, one summer visitor, two passage migrants and one year round visitor, while in summer there were 36 species of resident birds, one summer visitor, two passage migrants and one year round visitor.

The occurrence of birds in the area was classified as common, scarce and rare; the birds observed in numbers less than 5 were rated as rare, between 5 and 15 as scarce and above 15 as common. As per these criteria, there were 46 common in winter and 28 in summers; 19 scarce in winter and 6 in summer and 10 rare in winter and 6 in summers.

The winter migrants start arriving in the area in late August and depart by April. As regards the breeding of birds in the area in summer, it requires further investigation and could not be observed in the brief survey.

Figure 6 – Number of species, families and orders observed during winter and summer season

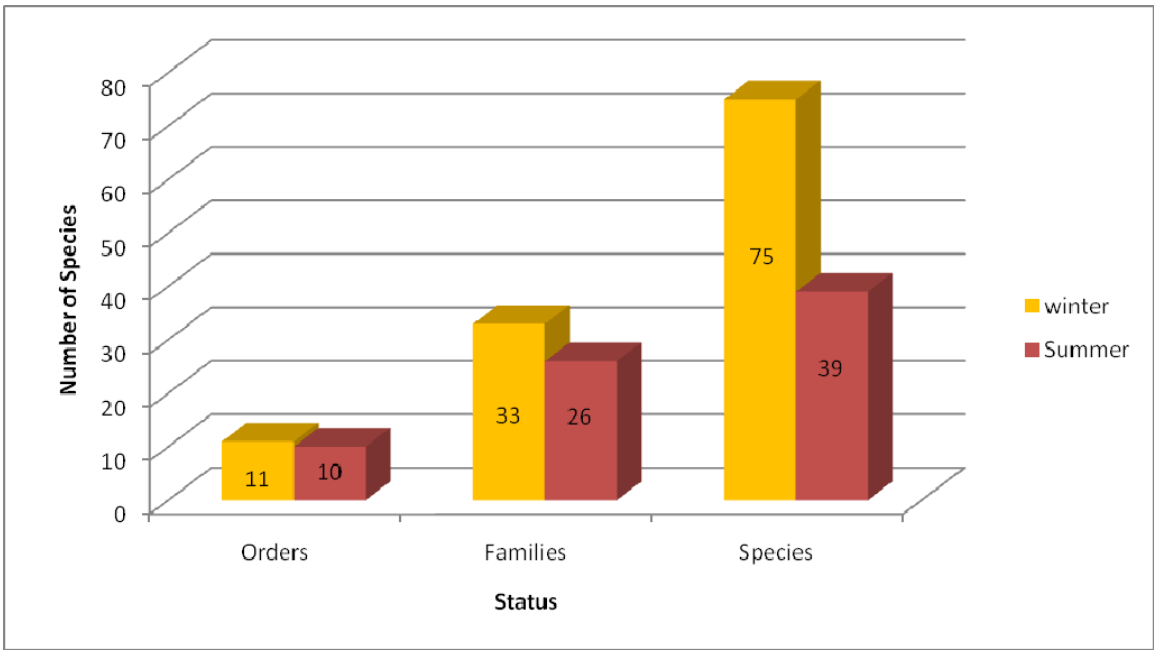


Figure 7 – The abundance of the number of species during the summer and winter season

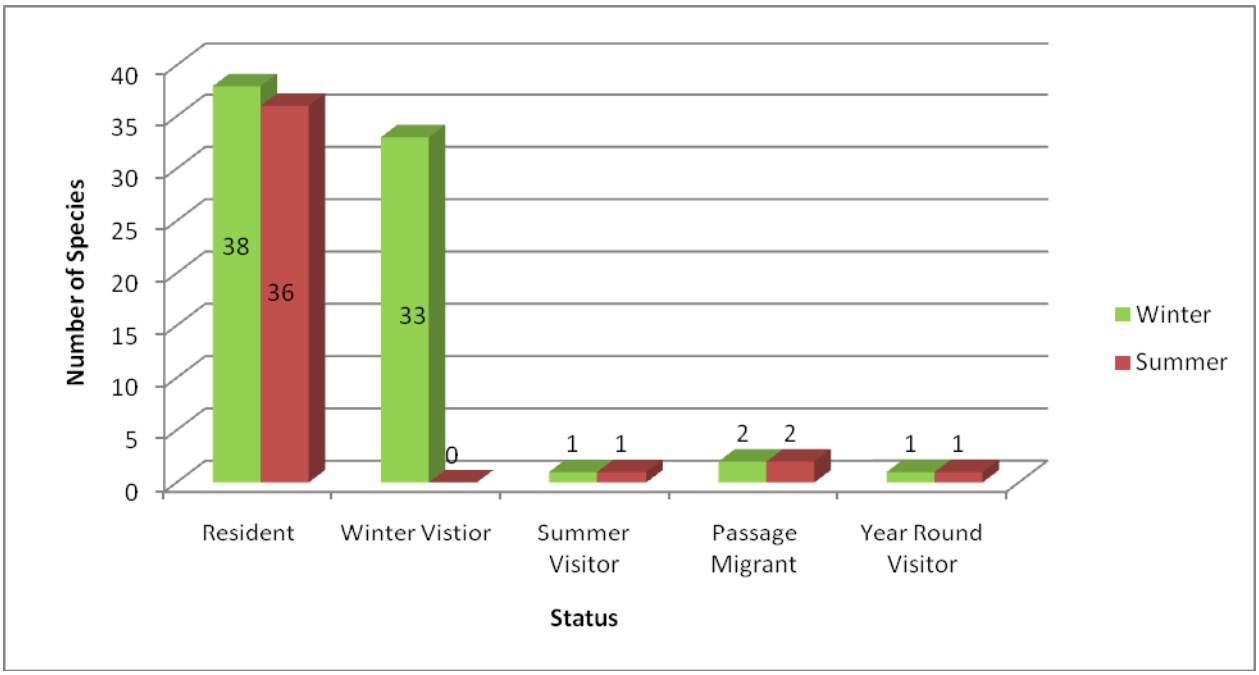


Figure 8 – Representation of birds recorded during the two seasons

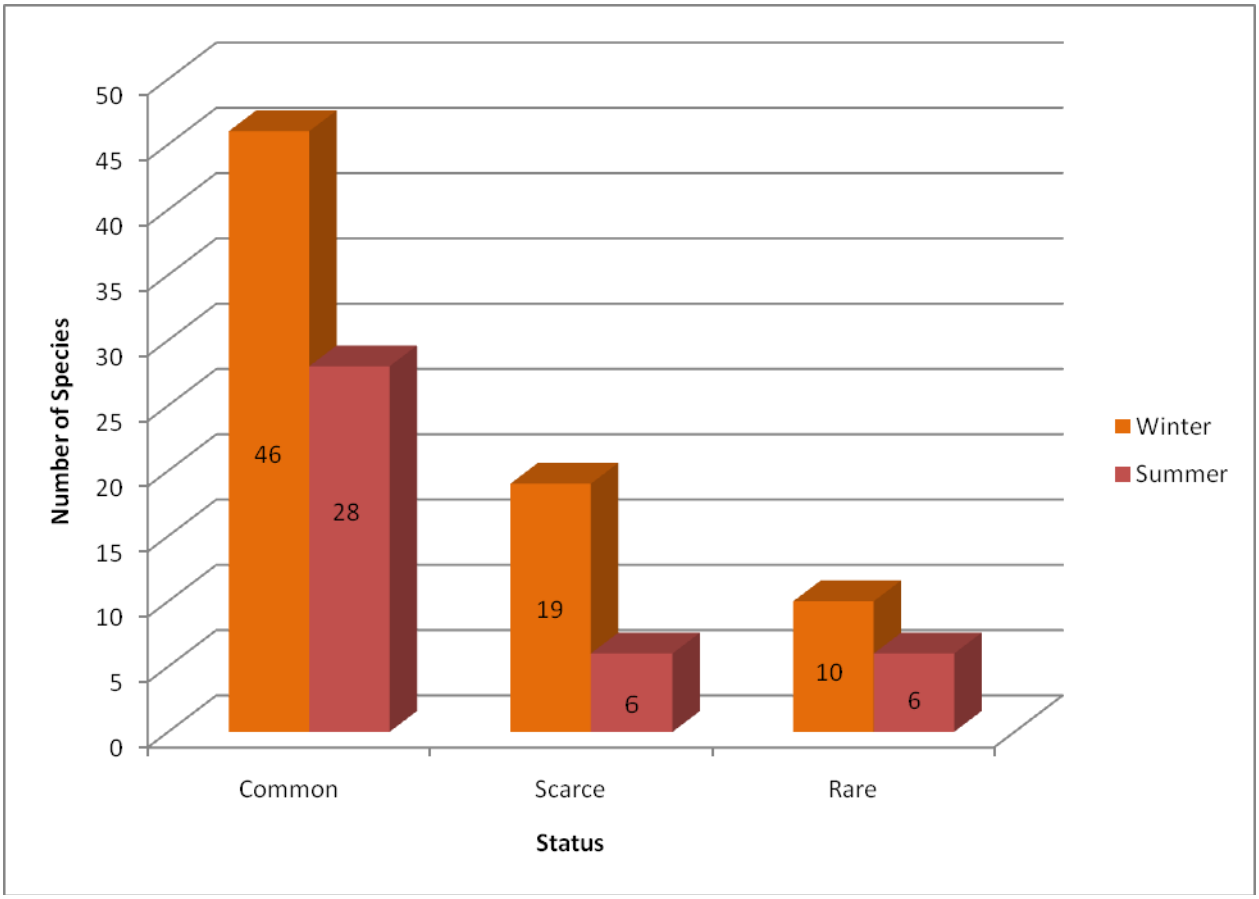
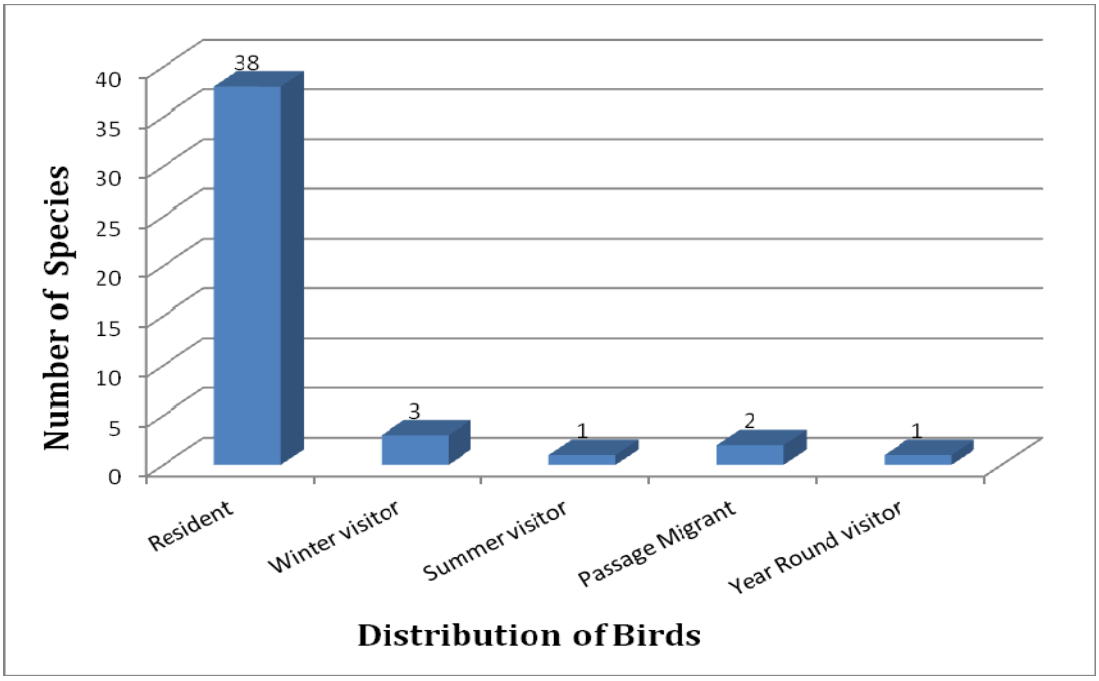


Figure 9 – Number of bird species recorded from Manchhar against season and occurrence



3.4.5 Threats and recommendations

3.4.5.1 Threats

- Hunting/trapping/poaching of birds is the main threat, especially in winter when the waterbirds visit the lake in large numbers.
- The wetland had become a neglected wetland and it had lost its importance as a main waterbird wintering site due to the effect of polluted water regularly coming into the lake through the Main Nara Valley Drain. The wetland has lost most of its vegetation and varied fish fauna.
- There is excessive cattle grazing in the area.
- There is also some domestic sewage incoming from fishermen boats, hotels and residential area.
- There is a lot of disturbance due to fishing activities, tourism and recreation.
- There is the effect of eutrophication due to the incoming drainage water.
- There is effect of oil pollution due to the presence of a large number of fishing boats in the lake.

3.4.5.2 Recommendations

- Regular monitoring of the water quality is urgently needed.
- It is a very strong case for restoration of degraded wetland of potential international importance.
- Effective implementation of wildlife laws ensured.
- The lake can be restored provided effluent of MNV drain is stopped and release of fresh water from Indus is ensured or effluents are treated before releasing into Manchar. The dredging of lake may be undertaken to remove pollutants from the bottom of the lake.

3.5 Physico-chemical Properties of Water

3.5. 1 Sample Location

Samples were collected randomly on 27 January 2011, from three areas *i.e.*Goth Bubak, Zero Point Goth Khan Muhammad Mallah and Outlet Shawan. Map 5 shows the sampling location of water quality for Manchhar Lake.

3.5.2 Field Observations during water sampling

The water of Manchhar Lake is used for fishing, agriculture, drinking, washing and other domestic uses. The lake water has social and economic benefits as it provides recreation for the people and livelihood opportunities for local community in the form fisheries. The quality of water is affected due to anthropogenic actions which is a constant polluting source of the lake, as well as natural processes.

The discharge of contaminated water from the Main Nara Valley Drain (MNVD) has polluted the lake and the water is below the standards laid down by WHO.

The Chief Justice of Pakistan, Justice Iftikhar Chaudhry took suo action regarding the contamination of the MancharLake and issued directions to WAPDA to resolve the grievances of local population. WAPDA has put two treatment plants which is now producing potable water containing 150 – 200 parts per million (PPM) of total deposit solids (TDS) by treating saline effluent of Manchar Lake containing 4000 PPM. The villages which are presently benefiting from this plant include Manchar Bund, Ibrahim Radhoni, Moula Bux Mallah and few others. However, there is need to install a plant that would treat the effluents before it enter into the lake *(The News: May 11, 2011)*.

3.5.3 Results

The collected water sample was analysed in the Laboratory of GEL Pvt. Ltd. The analysis was completed on 30 May 2011.

I. The result of the analysis of water of Goth Bubak is given in Table below:

Table 8 –Chemical analysis test result of water of Goth Bubak

S. No	Parameters	Unit	NSDWQ	Concentration	Method	Remarks
1	pH value		6.5 – 8.5	7.92	pH meter	
2	Chloride	mg/l	>250	931.5	APHA 4500 Cl C	Higher
3	Conductivity	µS	-	4070	Conductivity meter	
4	Turbidity	NTU	5	3	Merck Method (077)	
5	Total Hardness	mg/l	<500	825.7	APHA 2340 C	Higher
6	Total Alkanity	mg/l	-	160	APHA 2320 B	
7	Cr (Hexa)	mg/l	0.05	0.05	Hach Method 8023	
8	Lead	mg/l	<0.05	BDL	AAS	
9	Zn	mg/l	5.0	BDL	AAS	
10	COD	mg/l	-	106	Hach Method 8000	
11	Iron	mg/l		BDL	AAS	
12	As	mg/l	<0.05	BDL	Merck Test (1,17927)	

Legend: NSDWQ = National Standards for Drinking Water Quality
BDL = Below Detection Limit

II. The result of the analysis of water of Zero Point Goth Khan Muhammad Mallah is given in Table below:

Table 9 – Chemical analysis result of water of Zero point , Manchhar

S. No	Parameters	Unit	NSDWQ	Concentration	Method	Remarks
1	pH value		6.5 – 8.5	7.76	pH meter	

2	Chloride	mg/l	>250	733.6	APHA 4500 Cl C	Higher
3	Conductivity	µS	-	2908	Conductivity meter	
4	Turbidity	NTU	5	33	Merck Method (077)	Higher
5	Total Hardness	mg/l	<500	728.8	APHA 2340 C	Higher
6	Total Alkanity	mg/l	-	136.3	APHA 2320 B	
7	Cr (Hexa)	mg/l	0.05	0.04	Hach Method 8023	
8	Lead	mg/l	<0.05	BDL	AAS	
9	Zn	mg/l	5.0	BDL	AAS	
10	COD	mg/l	-	BDL	Hach Method 8000	
11	Iron	mg/l		BDL	AAS	
12	As	mg/l	<0.05	0.025	Merck Test (1,17927)	

Legend: NSDWQ = National Standards for Drinking Water Quality
BDL = Below Detection Limit

III. The result of the analysis of water of Outlet Shawan is given in Table below:

Table 10 –Chemical analysis of water of outlet shawan, Manchhar

S. No	Parameters	Unit	NSDWQ	Concentration	Method	Remarks
1	pH value		6.5 – 8.5	7.81	pH meter	
2	Chloride	mg/l	>250	886.7	APHA 4500 Cl C	Higher
3	Conductivity	µS	-	3070	Conductivity meter	
4	Turbidity	NTU	5	14	Merck Method (077)	Higher
5	Total Hardness	mg/l	<500	764.2	APHA 2340 C	Higher

6	Total Alkanity	mg/l	-	154.2	APHA 2320 B	
7	Cr (Hexa)	mg/l	0.05	0.01	Hach Method 8023	
8	Lead	mg/l	<0.05	BDL	AAS	
9	Zn	mg/l	5.0	BDL	AAS	
10	COD	mg/l	-	58	Hach Method 8000	
11	Iron	mg/l		BDL	AAS	
12	As	mg/l	<0.05	0.1	Merck Test (1,17927)	

Legend: NSDWQ = National Standards for Drinking Water Quality
BDL = Below Detection Limit

The Microbiological analysis of the water of above three sites was also undertaken and the result is as under:

Table 11- Microbiological Analysis Result

Site I: Goth Bubak

S. No.	Parameters	Recommended Value [as per WHO/USEPA for Drinking Water]	Results
01	Faecal Coliform	0 cfu/100 ml	125 cfu/100 ml

Remarks: The water is microbiologically unsatisfactory for human consumption.

Site II: Zero Point, Goth Khan Muhammad Mallah

S. No.	Parameters	Recommended Value [as per WHO/USEPA for Drinking Water]	Results
01	Faecal Coliform	0 cfu/100 ml	64 cfu/100 ml

Remarks: The water is microbiologically unsatisfactory for human consumption.

Site III: Outlet Shawan

S. No.	Parameters	Recommended Value [as per WHO/USEPA for Drinking Water]	Results
01	Faecal Coliform	0 cfu/100 ml	148 cfu/100 ml

Remarks: The water is microbiologically unsatisfactory for human consumption.

3.5.4 Discussion

The pH value ranged from 7.76 to 7.92 that was neutral as per WHO guidelines of 6.5 – 8.5. The conductivity and higher level of Chlorides indicate the presence of high level of salts in water. The water is highly turbid as indicated by higher turbidity and unsuitable for human consumption. Due to turbidity, less sunlight is able to penetrate water surface and decrease in the amount of oxygen produced by aquatic plants.

Large quantities of fecal Coliform bacteria in water indicate a higher risk of pathogens being present in water. This causes some waterborne diseases like dysentery, typhoid fever, gastro-enteritis and hepatitis. This bacterium affects mostly on humans than the other aquatic life. The presence of fecal Coliform in freshwater is an indicator of contamination with human and animal excreta. Thus the water is harmful for human consumption.

CHAPTER 4: COMPARISON OF THE FOUR STUDY SITES

Mammals

Summary:

There are no significant difference in results of the summer and winter surveys of the study areas. The same 13 species were recorded from the study areas during both the winter and summer surveys. Moreover, most of the mammals particularly the nocturnal mammals were found more active during the summer surveys and the less active comparatively during the winter surveys. The reasons seem to be the homoeothermic and the hibernation factors for less activeness of mammals during winter.

The population estimation of animals was not attempted during this preliminary study. Estimating population of mammals required large efforts and maximum time which was inadequate.

Habitat loss and natural disasters affect wildlife species but the mammalian fauna of the area is facing serious threats from anthropogenic activities. The apparent low abundance of many large mammalian species is strong evidence that hunting and habitat degradation is having a considerable effect on their population.

A few wildlife species also create problems for the local people and thus are considered as problem species. The major concerns about wild animals in different sites are the damages to crops through agricultural pests like wild boar and porcupine and threats to human lives from mad / feral dogs and snake bites.

Some socio-economic issues like un- employment, less education, lack of awareness, less availability of basic needs eta. At different sites are also important factors in wildlife conservation and management in the study area.

Species identified

During surveys a total of 13 large and medium sized mammal species belonging to three orders (Carnivora, Artiodactyla, and Pholidata) were recorded from the four sites.
Ten species were recorded from Nara Wetland Complex, 5 from Manchhar, ten species from Kharochann and seven from Khyberani Forest.

Table 12- Species recorded from different sites

S.No	Common Name	Zoological Name	Local Name	Order
1	Asiatic Jackal	*Canis aureus*	Giddar	Carnivora
2	Jungle Cat	*Felis chaus*	Jang Billo	Carnivora
3	Fishing Cat	*Prionailurus viverrinus*	Mash Billo	Carnivora
4	Indian Desert Cat	*Felis sylvestris ormata*	Sahrai Billi	Carnivora
5	Bengal Fox	*Vulpes bengalensis*	Lumar	Carnivora
6	Desert Fox or Red Fox	*Vulpes vulpes pusilla*	Sahrai Lumar	Carnivora
7	Smooth coated Otter	*Lutrogale perspicillata*	Lunher	Carnivora
8	Small Indian Mongoose	*Herpestes javanicus*	Neola	Carnivora
9	Grey Mongoose	*Herpestes edwardsi*	Neola	Carnivora
10	Small Indian Civet	*Viverricula indica*	Kasturi Billa	Carnivora
11	Hog Deer	*Axis porcinus*	Para	Artiodactyla
12	Indian Wild boar	*Sus scrofa*	Suar	Artiodactyla
13	Indian Pangolin	*Manis crassicaudata*	Bagra, Silu	Pholidota

Observation records:
Out of the total 13 recorded species, 6 species were observed directly while the remaining 7 species were recorded on the basis of indirect evidences such as the presence of fecal materials, foot prints and interviews of local residents and wildlife watchers. The observation records of different mammals found in all the five sites are given in the Table13.

Table 13 Observation Record of Large Mammals

S. No.	Species	Direct Observations	Indirect observations through tracks, feces and interviews from local people

	NWC	ML	KC	KF	NWC	ML	KC	KF
Asiatic Jackal	✓	✓	✓	✓	✓	✓	✓	✓
Jungle Cat	✓	✓	✓	✓	✓	✓	✓	✓
Fishing Cat					✓		✓	
Desert Cat					✓		✓	
Bengal fox					✓		✓	✓
Red fox	✓	✓			✓	✓		
Smooth coated otter					✓			
Small Indian Mongoose	✓	✓	✓	✓	✓	✓	✓	✓
Grey Mongoose	✓	✓	✓	✓	✓	✓	✓	✓
Small Indian Civet							✓	
Indian Wild boar	✓		✓	✓	✓		✓	✓
Hog Deer					✓			✓
Indian Pangolin							✓	

Legend: NWC = Nara Wetland Comlex, ML = Manchar Lake, KC = Kharochann, KF = Khyberani Forest

Conservation status of mammal species

According to IUCN International Red List 2011, Asiatic Jackal, Jungle Cat, Desert Cat, Bengal Fox, Red Fox, Grey Mongoose, Small Indian Civet, Indian Wild Boar are categorized as Least Concern (LC), Fishing Cat, Smooth Coated Otter, Small Indian Mongoose as Vulnerable (VU), Hog Deer as Endangered (EN) and Indian Pangolin as Near Threatened (NT).

Seven species are protected in Sindh under Sindh Wildlife Protection Ordinance 1972. Six species are enlisted in Appendix II while three species in Appendix I of the CITES category 2011. The conservation status of different mammals found at Indus for All Programme sites is given in Table 14 below.

Table14Conservation status of mammals found at sites

S.NO	Mammalian Species Recorded	IUCN Red List 2011	Sindh Wildlife Protection Ordinance 1972	CITES Category 2011
1	Asiatic Jackal	LC	-	-

2	Jungle Cat	LC	P	Appendix II
3	Fishing Cat	VU	P	Appendix II
4	Desert Cat	LC	P	Appendix II
5	Bengal Fox	LC	-	Appendix I
6	Red Fox	LC	-	
7	Smooth coated Otter	VU	P	Appendix II
8	Small Indian Mangoose	VU	-	Appendix II
9	Grey Mangoose	LC	-	
10	Small Indian Civet	LC	P	Appendix I
11	Indian Wild Boar	LC	-	
12	Hog Deer	EN	P	Appendix I
13	Indian Pangolin	NT	P	Appendix II
Legends: EN= Endangered, VU= Vulnerable, NT= Near Threatened, LC= Least Concern				

Species Diversity

Looking at the diversity index over the four sites Nara Wetland Complex and Kharochann holds the highest level of diversity of mammals followed by Khebrani Forest. Given the variety of habits at Nara Wetland Complex (desert, wetland and forest) it is not surprising that this site holds the highest index. Similarly Kharochann comprises of both terrestrial and marine habitats which results in a high diversity index despite apparent environment degradation both inland and in the creeks. Even with some variance in diversity the evenness of diversity across the sites is quite regular, except for Nara Complex. These indexes do not take into account the diversity across seasons, something that is discussed further on in this chapter.

Comparison of Species observed during summer and winter

Number of animals recorded during summer and winter surveys are merely rough estimates and not the actual populations (Shown in Table 15 - 18). The last column in the following tables showing total animals is not reflecting the total population of different species at different sites. Rather it is just the sum of observed animals observed during summer might be the same counted or observed during winter.

Table 15 -Mammals observed at Nara Wetlands Complex during summer and winter Surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	4	1	5
2	Jungle Cat	1	-	1
3	Red Fox	1	-	1
4	Small Indian Mongoose	5	5	10
5	Grey Mongoose	3	1	4
6	Indian Wild Boar	4	-	4

Table 16 -Mammals observed at Khyberani Forest during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	5	2	7
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	2	2	4
4	Grey Mongoose	1	-	1
5	Indian Wild Boar	3	-	3

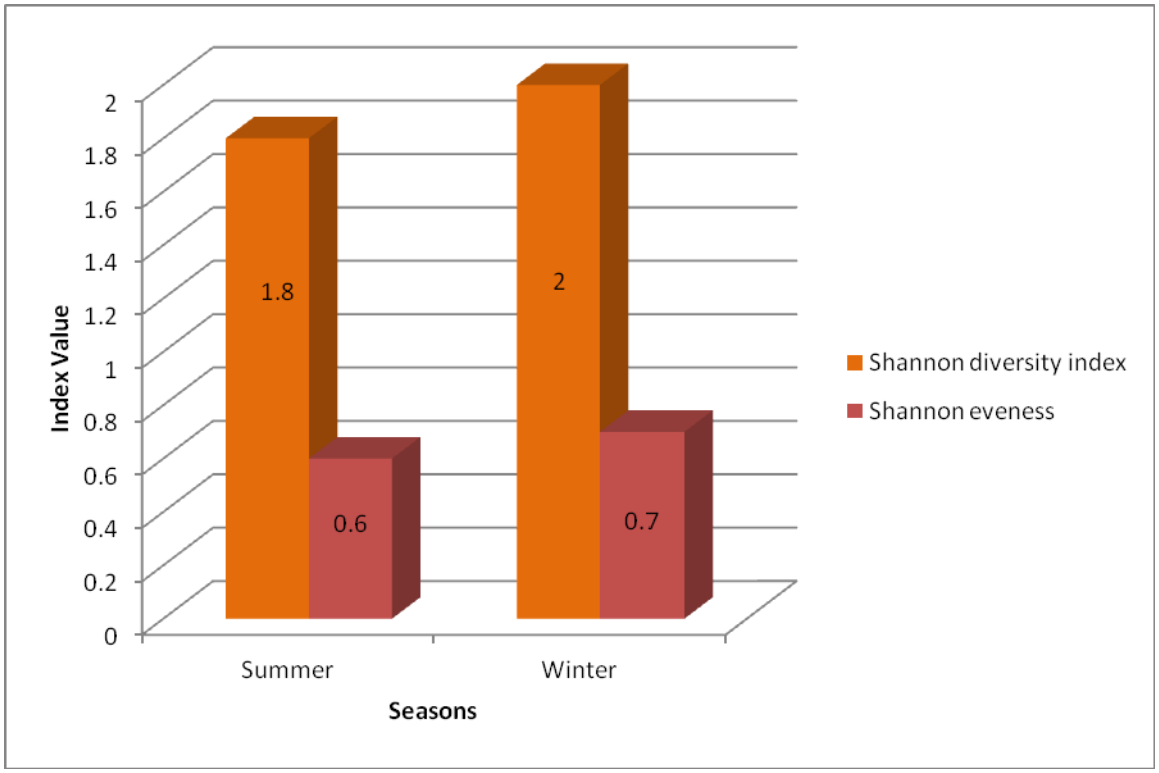
Table 17 -Mammals observed at Manchhar Lake during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	2	-	2
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	1	1	2
4	Grey Mongoose	1	-	1

Table -18 Mammals observed from Kharochann during summer and winter surveys

S.NO	Common Name	Winter	Summer	Total Animals
1	Asiatic Jackal	3	-	3
2	Jungle Cat	1	-	1
3	Small Indian Mongoose	3	2	5
4	Grey Mongoose	1	-	1
5	Indian Wild Boar	4	-	4
6.	Indian Pangolin	1	-	1

Figure 10 - Shannon diversity and Evenness index over all sites for summer and winter



There was more diversity of medium and large mammals in winter than summer across the four sites. There may be several reasons for this such as mammals were more active in winter foraging for food or were more detectable due to less vegetation on the ground.

Population Estimation

Populations of large mammals were not estimated as sufficient data in this respect could not be collected.

Assessment of level of threats to mammals at different study sites

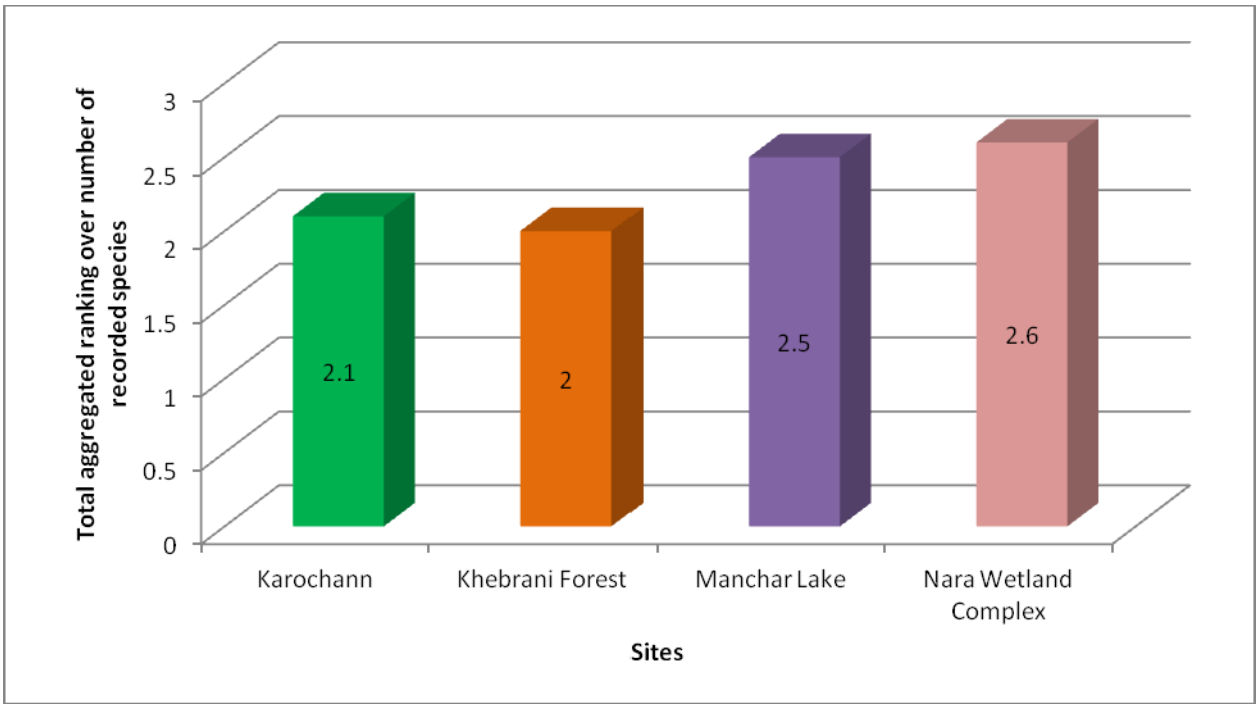
Various threats to different mammals were identified at four different study sites that include; habitat destruction, illegal hunting, poaching, live trapping, food competition, lack of awareness, law and order situation, weak enforcement of wildlife laws etc. Based on indirect and direct observations in the field and after interviewing different people from local communities and wildlife watchers and forest guards an assessment was made to indicate the level of threats to every mammal species in four sites.

1= no threats, 2= minor threats, 3= moderate threats, 4= highly threatened, 5= critically threatened

Table 19 Assessment of level of threats to mammals at different study sites

S.No	Common Name	Kharochann	Khyberani Forest	Manchar Lake	Nara Wetland Complex
1	Asiatic Jackal	2	2	2	2
2	Jungle Cat	2	2	3	3
3	Fishing Cat	3	-	-	3
4	Indian Desert Cat	3	-	-	3
5	Bengal Fox	3	2	2	-
6	Desert Fox or Red Fox	3	-	2	3
7	Smooth coated otter	-	-	-	5
8	Small Indian Mongoose	1	1	1	1
9	Grey Mongoose	1	1	1	1
10	Small Indian Civet	3	-	-	-
11	Hog Deer	-	5	-	4
12	Indian Wild Boar	1	1	-	1
13	Indian Pangolin	3	-	-	-

Figure 11 Aggregated threat ranking adjusted against number of species recorded from each site



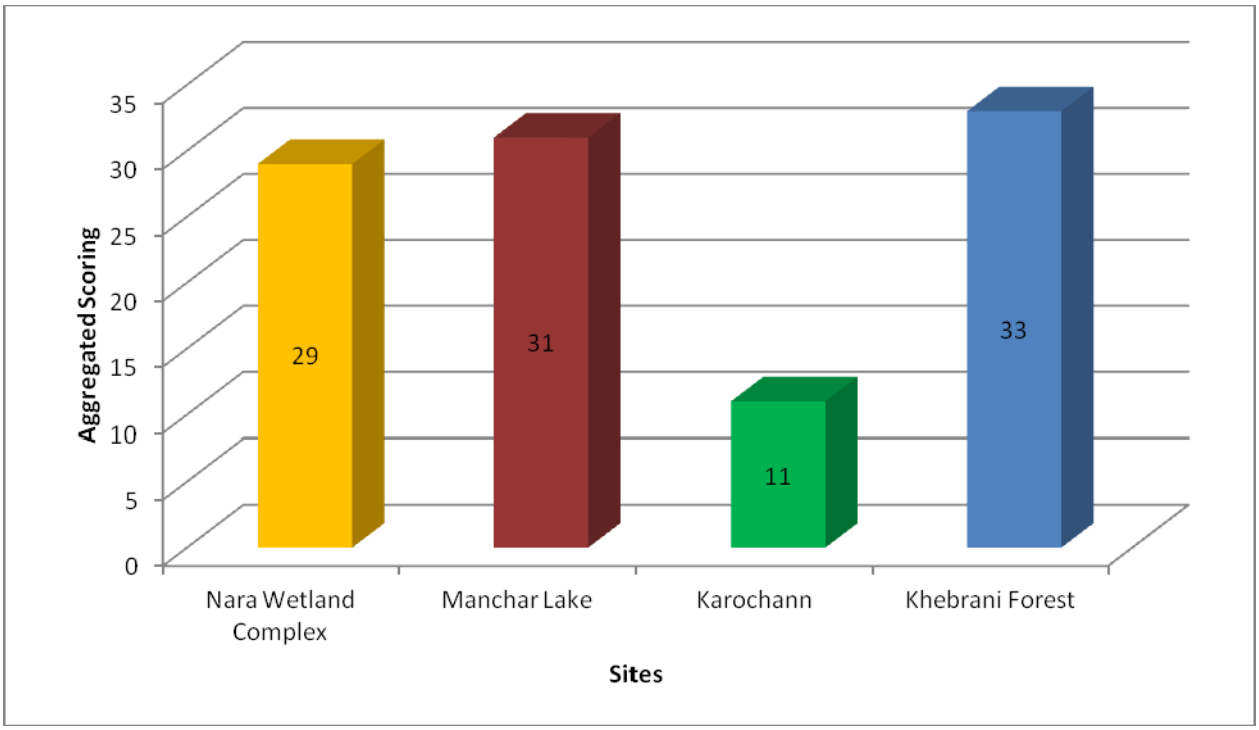
Khebrani Forest and Manchar Lake had the highest averaged disturbance factor against the species that were recorded there. Though this is an arbitrary scoring it does give an indication over the overall threat to large mammals at each site. Figure 22 gives the aggregated score for all sites.

Table 20 - Threats Ranking for Large Mammals at Sites

S.No	Nature of Threats	Nara Wetland Complex	Manchar Lake	Kharochann	Khyberani Forest
1	Habitat removal/ degradation	3	4	1	4
2	Wood cutting	2	1	2	5
3	Hunting Pressure	5	4	1	5
4	Poaching/ Live trapping	3	3	1	3
5	Food Competition with livestock	2	2	-	2
6	Use of fie arms	4	4	-	5
7	Pollution	2	5	3	1
8	Weak enforcement of wildlife laws	5	5	2	5
9	Law and order situation	1	1	-	3
10	Natural threats	2	2	1	-

	Total Score	29	31	11	33
1 = low, 2 = medium, 3 = average, 4 = significant, 5 = high					

Figure 12 Aggregated score for distribution factors across sites



4.2 Small mammals

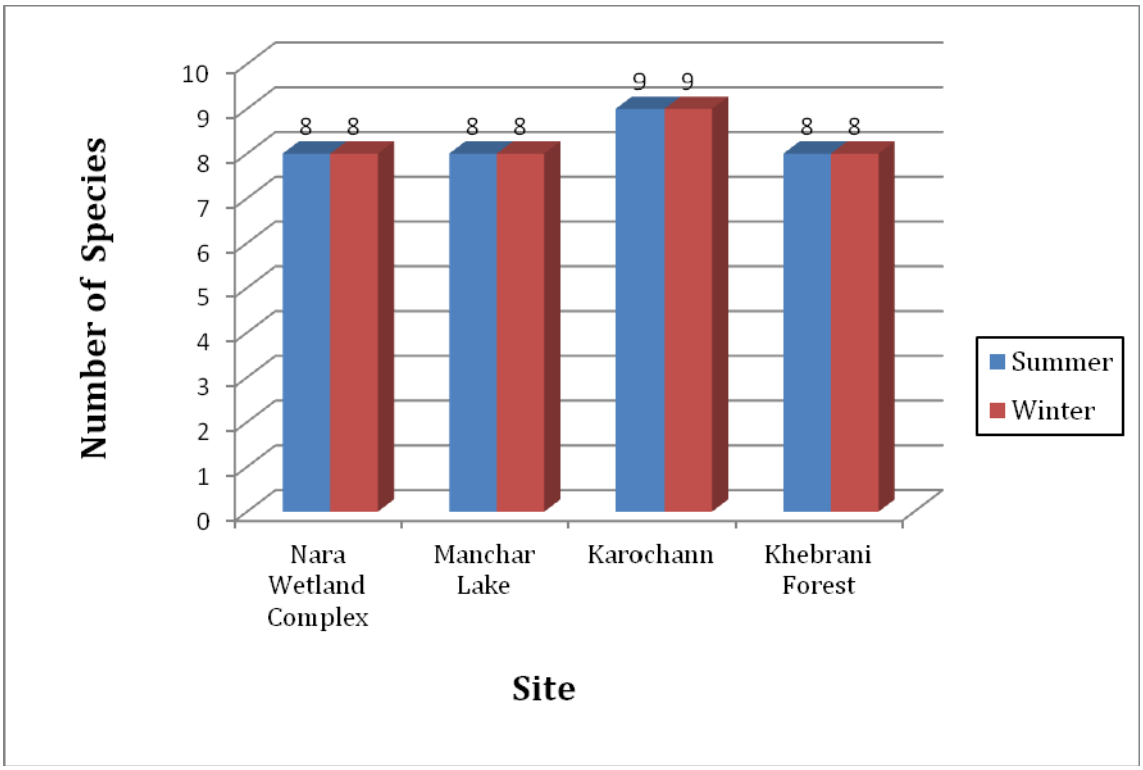
4.2.1Species recorded

A total of 11 small mammal species were observed from the four sites, 8 from Nara Wetland Complex, 8 from Manchar Lake, 9 from Kharochann and 8 from Khebrani Forest. Most of small mammals are widespread and have been recorded from all of the four sites. The widespread small mammals were Palm Squirrel, Common House Mouse, Indian Gerbil, Indian Desert Gerbil, Indian crested Porcupine and Desert Hare. The species which is restricted to only one site were Mole rat Kharochann and Indian hedge hog at Khyberani Forest. Table below gives an account of species found at each side.

Table 21- LIST OF SMALL MAMMAL SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchar Lake		Karochann		Khebrani Forest	
		W	S	W	S	W	S	W	S
1	Palm Squirrel	+	+	+	+	+	+	+	+
2	Common Rat					+	+	+	+
3	Common House Mouse	+	+	+	+	+	+	+	+
4	Indian Mole Rat					+	+		
5	Indian Gerbil	+	+	+	+	+	+	+	+
6	Indian Desert Jird	+	+	+	+	+	+	+	+
7	Balochistan Gerbil	+	+	+	+	+	+		
8	Indian crested Porcupine	+	+	+	+	+	+	+	+
9	Desert hare	+	+	+	+	+	+	+	+
10	Indian hedgehog							+	+
11	Long eared Hedge hog	+	+	+	+				

Figure 13 below shows the number of small mammal species recorded at each site over winter and summer.



4.2.2 Feeding habits

The feeding habits of small mammals varied over sites with no particular trend over sites. Figure 26 and 27 give details of the percentage of species in each site against the main feeding habits.

Figure 14 – Percentage of species recorded for each site over feeding habit

	Common Name	Karochann			Khebrani Forest			Manchar Lake			Nara Wetland		
		W	S	%	W	S	%	W	S	%	W	S	%
1	Grainivore	7	7	*77.7*	4	4	*57.1*	5	5	*62.5*	5	5	*62.5*
2	Herbivore	2	2	*22.2*	2	2	*28.5*	2	2	*25*	2	2	*25*
3	Insectivore	-	-	*0*	1	1	*14.3*	-	-	*0*	-	-	*0*
4	Omnivore	-	-	*0*	-	-	*0*	1	1	*12.5*	1	1	*12.5*

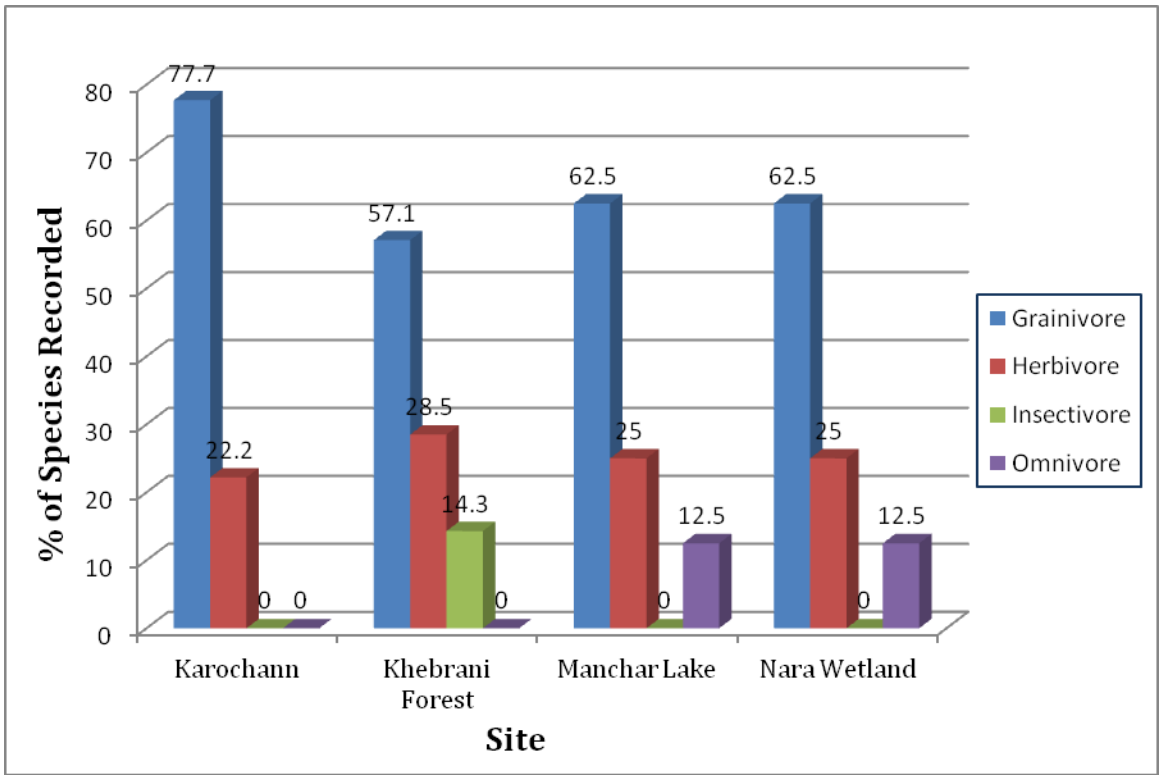
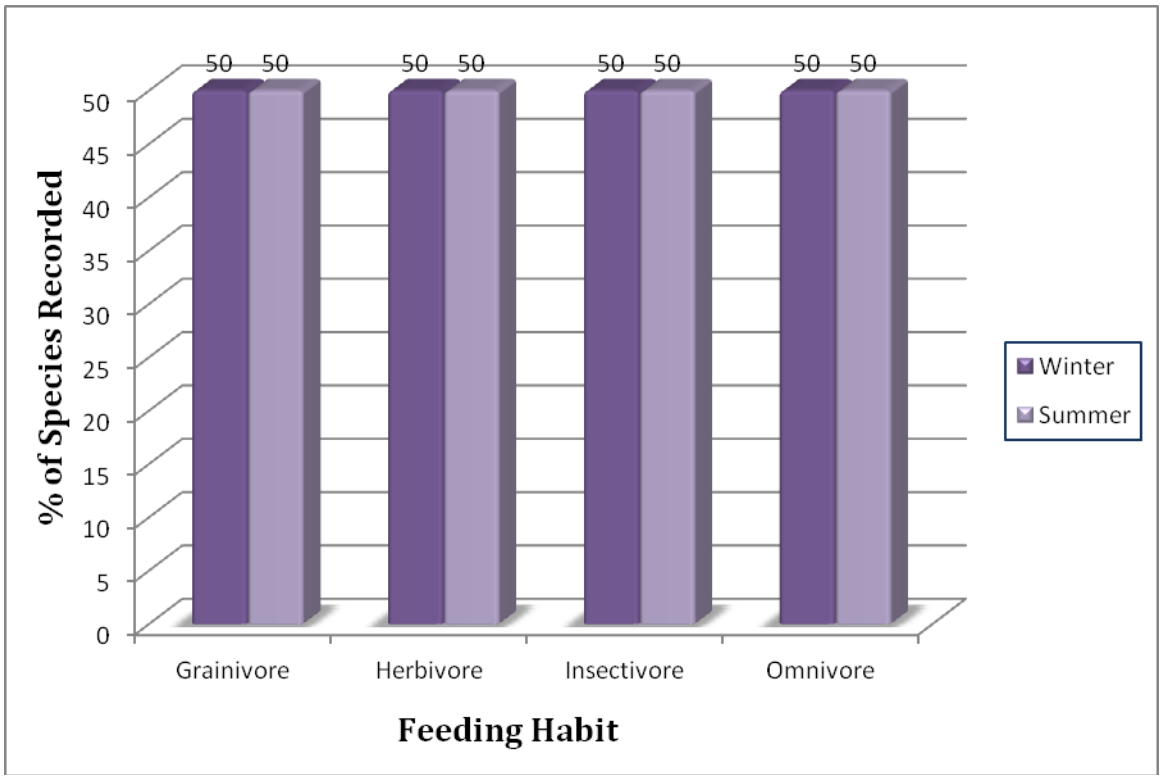


Figure 15 – Percentage of species recorded for each side over feeding habits

Figure 16 – Percentage of species recorded over season against feeding habits


50 50
50 50
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% of Species Recorded
Grainivore
Herbivore
Insectivore
Omnivore
Feeding Habit
Winter
Summer

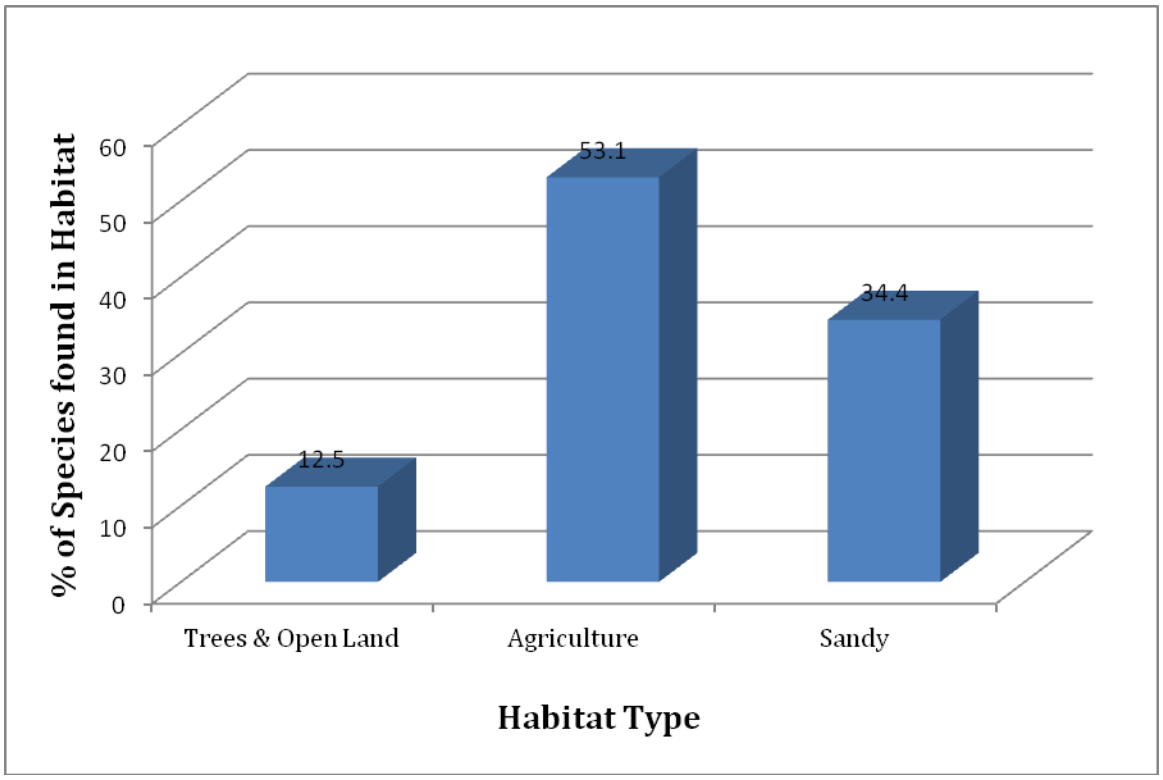


Figure 17- Percentage of species observed according to habitat

4.2.3 Habitat

Over the four sites agriculture habitat supported the most species with more than 53% of all records being taken from agriculture habitats followed by sandy habitat (34.4%) and open land (12.5%)

	Common Name	Karochann			Khebrani Forest			Manchar Lake			Nara Wetland		
		W	S	%	W	S	%	W	S	%	W	S	%
1	Common	8	8	*28.5*	7	7	*25*	7	7	*25*	6	6	*21.5*
2	Scarce	1	1	*25*	0	0	*0*	1	1	*25*	2	2	*50*
3	Rare	0	0	*0*	0	0	*0*	1	1	*100*	0	0	*0*

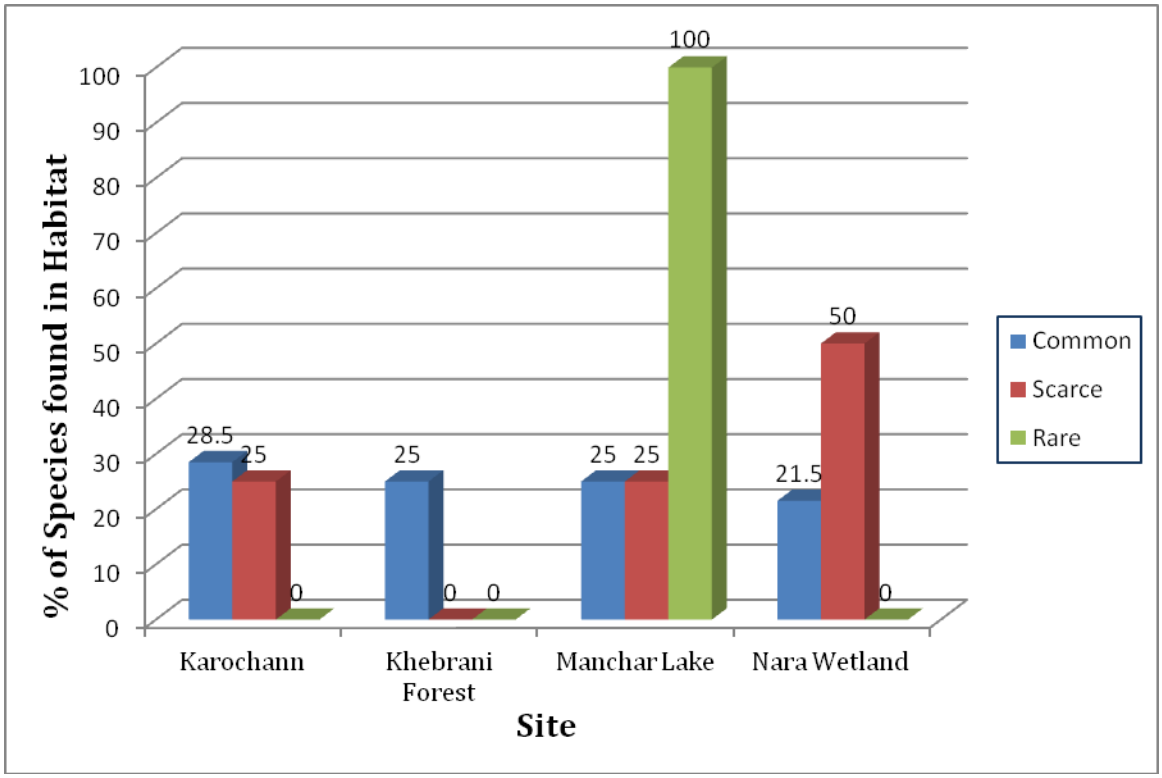
4.2.2 Status of small mammals across the survey sites

All the small mammals recorded during the survey were categorized as Common or of Least Concern. There are no rare, endangered or endemic species though many parts of the country are data deficient for several species so these categories are still quite speculative. There was no obvious trend or dominance of the two categories.
Figues 29 and 30 show the results over site and season

4.3 Reptiles and amphibians

4.3.1Summary

During surveys, 38 species of reptiles and amphibians were observed. Among them, 27 species were recorded from Nara Wetland Complex, 20 from Manchar Lake, 14 from



Kharochann and 11 from Khebrani forest. Even though this was a preliminary and brief survey so there is possibility that more species might be observed during the future in a detailed ecological survey.

The detailed biological assessment with regard to the reptiles and amphibians were made on four sites *viz.* Chotiari Reservoir, Kinjhar Lake, Pai Forest and Keti Bunder by the Indus for All Programme in 2007 - 2008. Then, during the study 27 species of amphibians and reptiles were recorded from Keti Bunder, 23 species from Kinjhar, 31 from Chotiari Reservoir and 18 species from Pai Forest.

Being excellent biological indicators, the amphibians and reptiles respond quickly to weather or climate changes and take refuge into burrows in case of danger and unfavourable conditions. The amphibians and reptiles are mostly nocturnal species and therefore survey during night is more appropriate for study of reptiles. However due to some constraints, night survey could not be undertaken at few sites. Amphibian and reptilian activity is also restricted to specific time of the day and specific season of the year. When proper time and habitat for survey is not considered then there is possibility of sighting of species become minimal.

There is always a need of consistent monitoring of amphibian and reptilian species during their activity period, over the months for several years to comprehensively record the potential herpeto-fauna. This was indeed the limiting factor in such short duration surveys. All these factors indicate the practical difficulties in the documentation of these species. There is a great need to carry out more work in order to add to the existing lists. The future studies need more time to effectively prepare herpeto-faunal inventory of the area.

4.3.2 Species recorded

A total of 37 species of reptiles and amphibians were recorded from the four sites during present study. Among them, 27 species of Amphibians and reptiles were recorded from Nara Wetland Complex, 20 species from Manchar Lake, 14 species from Kharo chann and 11 species from Khebrani Forest. There was no difference in number of species in winter and summer surveys, except one additional species from Manchar was recorded in summer.

Indian Garden Lizard, Bengal Monitor, Indian Cobra, Saw scaled Viper and Skittering Frog were the only species recorded from all the four sites. Mugger Crocodile, Brown River Turtle, Spotted Pond Turtle, Glossy bellied Racer and Checkered Keelback were only recorded from Nara Wetland Complex. Similarly, Brilliant Agama, Yellow-headed Rock Agama, Red throat Agama, Punjab Snake-eyed Lacerta and Indus valley Wolf Snake were only recorded from Manchhar Lake. Warty Rock Gecko and Bronze Grass Skink were only observed at Khyberani Forest. There were not any exclusive species in Kharochann.

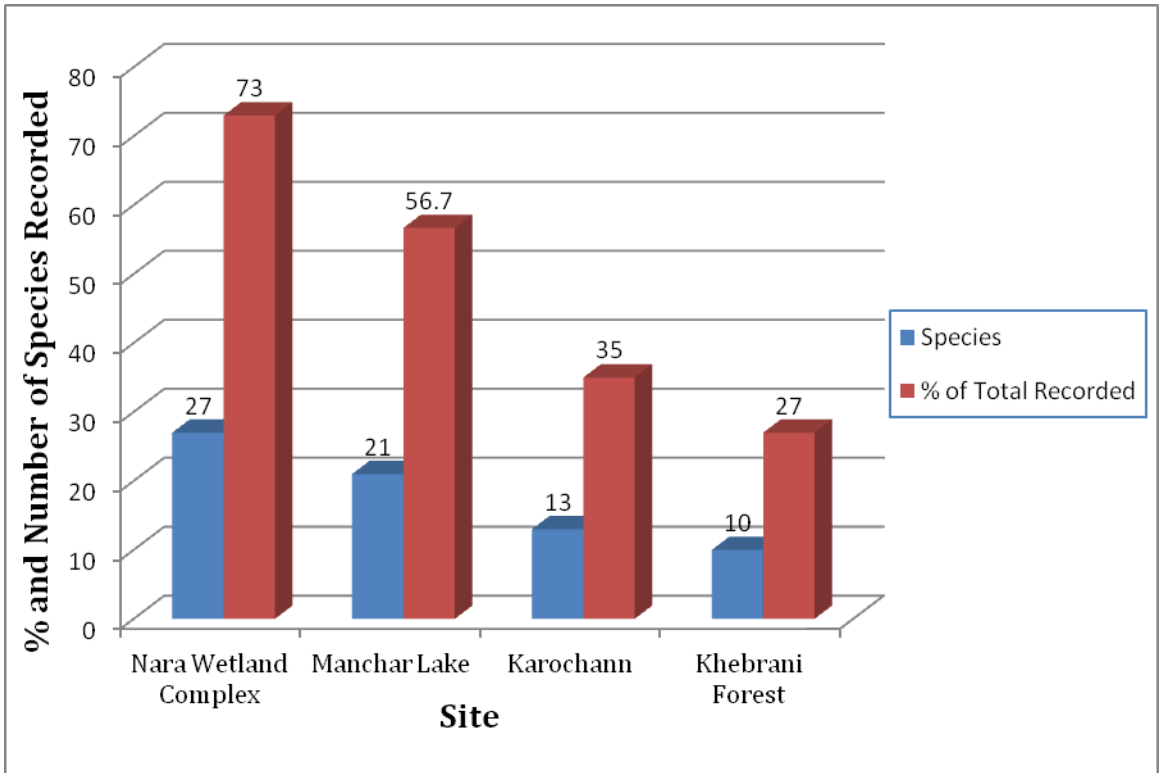
The list of species recorded from each site is given in the following Table.

Table 22 - LIST OF REPTILES AND AMPHIBIA SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchar Lake		Karochann		Khebrani Forest	
		W	S	W	S	W	S	W	S
1	Mugger Crocodile	+	+						
2	Saw-back Turtle	+	+			+	+		
3	Brown River Turtle	+	+						
4	Spotted Pond Turtle	+	+						
5	Indian Soft-shell Turtle	+	+						
6	Indian Flap-shell Turtle	+	+	+	+			+	+
7	Tree or Indian Garden Lizard	+	+	+	+	+	+	+	+
8	Afghan Ground Agama	+	+	+	+	+	+		
9	Brilliant Agama			+	+				
10	Yellow-headed Rock Agama			+	+				
11	Red throat Ground Agama				+				
12	Yellow-bellied House Gecko	+	+	+	+	+	+		
13	Spotted Indian House Gecko	+	+	+	+				
14	Keeled Rock Gecko	+	+	+	+				
15	Warty Rock Gecko							+	+
16	Three fingered Sand fish	+	+	+	+				
17	Indian Sand Swimmer	+	+						
18	Bengal Monitor	+	+	+	+	+	+	+	+
19	Indo-Pak Desert Monitor	+	+	+	+				
20	Bronze Grass Skink	+	+					+	+

21	Indian fringe-toed Sandy Lizard	+	+	+	+				
22	Punjab Snake-eyed Lacerta			+	+				
23	Indian Cobra	+	+	+	+	+	+	+	+
24	Saw scaled Viper	+	+	+	+	+	+	+	+
25	Indian or Common Krait					+	+		
26	Indian Sand boa	+	+	+	+				
27	Afro-Asian Sand Snake					+	+		
28	Rope Snake or Dhaman					+	+		
29	Indus valley Wolf Snake			+	+				
30	Sind Awl-headed Sand Snake	+	+						
31	Cliff Racer	+	+	+	+				
32	Glossy bellied Racer	+	+						
33	Checkered Keelback	+	+						
34	Marbled Toad	+	+	+	+			+	+
35	Bull frog	+	+			+	+	+	+
36	Skittering Frog	+	+	+	+	+	+	+	+
37	Indus valley Toad					+	+		

Figure 19 – Percentage of species and total species number recorded from each site



4.3.3 Species diversity

The following tables and figures examine the diversity of each site plus the evenness across the sites. This analysis incorporates both winter and summer season data.

The results in Table 23 show that Manchhar Lake has the highest species account, followed by Nara Wetland Complex, Kharochann and Khebrani Forest. However the evenness analysis shows that Kharochann has more evenness ratio followed by Nara Wetland Complex, Manchhar Lake and Khyberani Forest.

Table 23 – Species Diversity

S. No.	Type of index	Nara Wetland Complex	Manchar Lake	Kharo chann	Khebrani Forest
1	Richness (number of species)	27	20	14	11

2	Evenness	1.29	0.92	1.41	0.75
3	Shannon Index	2.49	2.75	3.71	1.81
4	Mergalef Index	2.95	2.91	2.86	2.32

4.4 Avi-fauna

4.4.1 Summary

4.4.1.1 Nara Wetland Complex

The Nara Wetland Complex comprises of Nara Canal and a complex of about 225 small, medium and large wetlands or *dhands* on either side of the canal. These wetlands are either permanent or seasonal and are fresh water to brackish or saline. The majority of wetlands has an area of about 200 ha and is surrounded by sand dunes. Many dry out completely during winter and early spring. The area provides diverse habitat for a wide variety of birds which include lakes, marshes, desert, agriculture areas, fish ponds, wasteland and villages.

The wetlands of the Nara complex are the important wintering and staging ground of the migratory water birds that hosts a variety of rare and endangered bird fauna.

A total of 118 species of birds belonging to 13 orders and 37 families were recorded. Out of 118 species recorded, 53 are winter migrants, 59 resident, 4 passage migrants and two year round visitor birds. These include the vulnerable species, Marbled Teal *(Anas angustirostris)* and Near Threatened species of Ferruginous Duck *(Aythya nyroca)*, and Indian Darter *(Anhinga rufa)*. The trend of presence of rare and endangered species recognizes the ecological importance of the area.

Ghalib *et al.* (2008) recorded 78 species of birds from the wetlands of the adjoining Nara Desert Wildlife Sanctuary. These also included the threatened species *viz.* Indian white beaked vulture and Houbara Bustard. They also recorded breeding of red wattled lapwing, white tailed plover, black winged stilt and black headed myna from the area.

Bailley (2005) recorded the occurrence of large pied wagtail *(Motacilla maderaspatensis)* and rock bunting *(Emberiza cia)* from Nara area which is for the first time from Sindh province.

4.4.1.2 Manchar Lake

It is the largest freshwater perennial lake formed in the natural depression. The lake is located in Dadu district of Sindh province. The lake is fed by two canals, the Aral Wah and the Danister from the river Indus. The lake also collects water from numerous small streams in the Kirthar mountain.

There has been continuous environmental degradation of this wetland and water of the lake is becoming saline. The diversion of water from the Indus and run off from Kirthar mountains have contributed to the reduction in fresh water supplies. At the same time, saline drainage water from agricultural fields in the surrounding areas also flows in to the lake. Pollution through the Main Nara Valley Drain (MNVD) is the main threat to the lake. It brings agricultural, municipal, industrial and saline water which is the constant polluting sources of the lake. The lake is also facing eutrophication.

Manchhar Lake has multiple habitats, North East is plain and predominant agronomical and South west consists of hilly and range land. The lake has been an important wintering and staging ground of migratory birds and home to resident birds. As many as 45,000 birds were counted in winter of 1991 and 32,000 birds in 2000 at this lake. But due to lake degradation the population is declining gradually.

4.4.1.3 Kharochann

Kharochann is a coastal area situated at a distance of about 220 km SE of Karachi in Thatta district. The area mostly consists of mangroves, marshes, fallow land, agricultural land, built up area, water channels, river bank, coastal area and the creek area. There are six major creeks in the area viz. Chann, Rohra, Ghora, Khichry, Mal and Wari creek.

The area is facing environmental degradation, particularly facing acute scarcity of fresh water and sea water intrusion. The intrusion is causing high salinity of the soil.

The area has great ecological significance and is the wintering ground of many species of waterbirds. Karochann is an important area for a variety of bird species. The area has significant biodiversity value, especially the wintering activities of avifauna. The migratory birds particularly the shorebirds, egrets and herons, gulls and terns, pelicans and flamingos that stopover for feeding, resting and roosting purpose. As many as 85 species of birds have been recorded from the area.

4.4.1.4 Khyberani Forest

Khebrani Forest is in Matiari District. It was a riverine forest which depended on Indus river water prior to the construction of Sukkur Barrage. It has been declared as a reserve forest by the Sindh Forest Department. The forest consists of 25 compartments and the total area of forest is about 3,000 acres.

A total of 61 species of birds belonging to 11 Orders and 30 Families were recorded. The Grey and Black Partridges are the key species of the area. Among the total recorded species 43 were resident and 18 migrants. Some less known species were recorded from the area such as Oriental Honey Buzzard, Northern Goshawk, Eurasian Sparrow Hawk and Long billed Pipit. Lot of open area is being converted into agriculture fields and thus habitat degradation is continued.

4.4.2 Species recorded

The total number of bird species recorded on each site is shown below.

Table24 – Total number of bird species recorded at each site

S. No.	Total No. of Species recorded on each site	No. of Species
1.	Nara Wetland Complex	118
2.	Manchar Lake	75
3.	Karochann	85
4.	Khebrani Forest	61

The total number of birds species recorded from all the 4 sites is 149 species. A total of 80 species of birds were recorded in summer and 146 species in winter. The total numbers of birds recorded in winter was 15,248 and in summer 6,824.

Table 25 - LIST OF BIRD SPECIES RECORDED FROM EACH SITE

	Common Name	Nara Wetland Complex		Manchar Lake		Karochann		Khaiberani Forest	
		W	S	W	S	W	S	W	S
1	Black necked Grebe	+							
2	Little Grebe	+		+	+				
3	White Pelican			+					
4	Large Cormorant	+	+	+					
5	Little Cormorant	+	+	+	+	+	+		
6	Indian Darter	+							
7	Grey Heron	+				+	+		
8	Purple Heron	+							
9	Indian Pond Heron	+	+	+	+	+	+	+	+
10	Cattle Egret	+	+	+	+	+	+	+	+

11	Large Egret	+		+		+			
12	Intermediate Egret	+	+	+		+		+	
13	Little Egret	+	+	+	+	+	+	+	+
14	Reef Heron	+	+	+	+	+	+		
15	Painted Stork					+			
16	Spoonbill			+					
17	Yellow Bittern	+							
18	Black Bittern		+				+		
19	Little Bittern	+	+						
20	Spoonbill			+					
21	Ruddy Shelduck	+							
22	Common Shelduck			+					
23	Marbled Teal		+						
24	Common Teal	+		+					
25	Mallard	+							
26	Gadwall	+							
27	Shoveller	+		+					
28	Common Pochard	+							
29	Ferruginous Duck	+							
30	Tufted Duck	+							
31	Common Kite	+	+	+	+	+	+	+	+
32	Blackwinged Kite	+		+	+	+			
33	Brahminy Kite	+		+		+	+		
34	Oriental Honey Buzzard							+	
35	Northern Goshawk							+	
36	Shikra	+		+	+	+	+	+	+
37	Eastern Sparrow Hawk							+	

38	Long legged Buzzard			+				+	
39	White eyed Buzzard	+					+		
40	Marsh Harrier	+	+	+		+			
41	Osprey	+				+			
42	Merlin							+	
43	Common Kestrel	+		+				+	
44	Grey Partridge	+	+	+	+	+	+	+	+
45	Black Partridge	+	+			+		+	
46	White breasted waterhen	+				+	+		
47	Indian Moorhen	+	+	+	+				
48	Purple Moorhen	+	+						
49	Common Coot	+		+					
50	Oystercatcher					+			
51	White tailed Plover	+		+					
52	Redwattled Lapwing	+	+	+	+	+	+		+
53	Yellow wattled Lapwing			+	+				
54	Little Ringed Plover	+		+		+	+		
55	Kentish Plover	+		+		+	+		
56	Lesser Sand Plover	+				+			
57	Greater Sand Plover	+							
58	Whimbrel	+				+			
59	Curlew	+		+		+			
60	Bartailed Godwit	+				+	+		
61	Common Redshank	+		+		+			
62	Marsh Sandpiper	+				+			
63	Greenshank	+				+			
64	Wood Sandpiper	+							

65	Common Sandpiper	+		+		+			
66	Common Snipe	+							
67	Little Stint	+		+		+			
68	Dunlin	+	+						
69	Ruff	+		+					
70	Black winged Stilt	+	+	+	+	+	+	+	+
71	Crab Plover	+				+			
72	Heuglin's Gull	+		+	+	+			
73	Brown headed Gull	+		+		+			
74	Black headed Gull	+	+	+		+	+		
75	Slenderbilled Gull	+	+	+		+	+		
76	Caspian Tern	+		+	+	+	+		
77	Gull billed Tern	+							
78	River Tern	+	+	+	+	+	+	+	+
79	Black bellied Tern	+				+			
80	Little Tern	+	+	+	+	+	+		
81	Sandwich Tern	+				+			
82	White cheeked Tern						+		
83	Chestnut bellied Sandgrouse			+	+				
84	Blue Rock Pigeon	+	+	+	+	+	+	+	+
85	Ring Dove	+	+	+	+	+	+	+	+
86	Little brown Dove	+	+	+	+	+	+	+	+
87	Crow Pheasant	+	+			+	+	+	+
88	Common Koel		+				+		
89	Rose ringed Parakeet		+				+		
90	Lesser Golden Woodpecker								+
91	Sykes's Night jar	+							+
92	Barn Owl	+							

93	Spotted Owlet	+	+						+
94	Pied Kingfisher	+	+	+	+	+	+		
95	Common Kingfisher	+	+	+		+		+	
96	White breasted Kingfisher	+	+	+	+	+	+	+	+
97	Green Bee eater	+	+	+	+	+	+	+	+
98	Blue-cheeked Bee eater		+						
99	Indian Roller	+	+	+	+	+		+	+
100	Common Hoopoe	+	+	+	+			+	
101	Desert Lark	+	+	+		+			
102	Greater Short toed Lark	+	+			+			
103	Crested Lark	+	+	+	+	+	+	+	+
104	Pale Martin	+		+		+		+	
105	Crag Martin	+	+			+			
106	Common Swallow	+		+		+		+	
107	Wire tailed Swallow		+				+		
108	Rufous tailed Shrike	+		+		+		+	
109	Southern Grey Shrike	+	+	+		+			
110	Bay backed Shrike	+							
111	Striated Shrike		+						
112	Black Drongo	+	+	+	+	+	+	+	+
113	Rosy Pastor			+	+				
114	Bank Myna			+	+		+	+	+
115	Indian Myna	+	+	+	+	+	+	+	+
116	Common Starling	+		+	+				
117	Tree Pie	+						+	+
118	House Crow	+	+	+	+	+	+	+	+
119	White Cheeked Bulbul	+	+	+	+	+	+	+	+
120	Red vented Bulbul	+	+					+	+
121	Common Babbler	+	+	+	+	+	+	+	+

122	Jungle Babbler	+	+					+	+
123	Striated Babbler	+							
124	White-browed Fantail Flycatcher	+				+		+	
125	Common Chiffchaff	+				+			
126	Clamarous Reed Warbler	+						+	
127	Yellow bellied Prinia	+	+					+	
128	Rufous vented Prinia	+	+	+				+	
129	Tailor Bird							+	+
130	Lesser Whitethroat	+						+	
131	Common Chiffchaff	+		+				+	
132	Greenish Warbler	+							
133	Bluethroat							+	
134	Black Redstart	+		+				+	
135	Pied Bushchat	+	+	+	+	+	+	+	+
136	Isabelline Wheatear	+				+		+	
137	Desert Wheatear	+		+		+			
138	Hume's Wheatear	+	+	+	+	+			
139	Indian Robin	+	+			+		+	+
140	Paddyfield Pipit							+	+
141	Longbilled Pipit							+	
142	White wagtail	+	+	+		+		+	
143	Yellow wagtail	+		+		+			
144	White browed Wagtail		+						
145	Purple Sunbird	+	+			+	+	+	+
146	House Sparrow	+	+	+	+	+	+	+	+
147	Jungle Sparrow	+	+			+		+	+
148	Streaked Weaver Bird		+						

149	House Bunting			+	+				

4.5 Physico-chemical properties of water

4.5.1 Summary of water quality

4.5.1.1 Drinking water

- **Manchhar Lake**

  Samples were collected from three sites in Manchhar area. The sample of lake water was collected from Goth Bubak, Zero Point at Goth Muhammad Mallah and from Outlet at Shawan. Samples were also collected for Microbiological analysis from the three sites.

  The total dissolved solid, TDS (or conductivity) is important along with pH in determining the water quality. The pH varies from 7.76 – 7.92 in samples which is acceptable range. The conductivity ranges from 2908µS – 4070µS. However, the turbidity (TSS) is higher on two sites i.e. 14 NTU and 33 NTU but within the WHO standard at Goth Bubak.

  The hardness of water ranges from 733.6 mg/l and 931 mg/l and above the prescribed standard of National Standards (WHO) which is less than 500 mg/l. The concentration of As was found to be high in water samples collected from Outlet Shawan which is higher than the permissible limit of WHO.

  The microbiological analysis of samples was also done which indicated the presence of Fecal coliform from 64 cfu/100 ml – 148 cfu/100 ml while the recommended value as per WHO/SEPA for Drinking water is 0 cfu/100 ml. The presence of Faecal coliform in freshwater is an indicator of contamination with human and animal excreta.

  The overall study shows that water quality of Manchhar lake is degraded. The water is polluted, specially due to waste water of agriculture and domestic wastes of surrounding areas coming through MNVD. The fishing and boating activities are also among the sources responsible for lake water quality deterioration.

- **Kharochann**

  Sampling was made during February 2011 from selected location at Kharochann.The main source of fresh water in Kharochann is hand pumps and well. Unfortunately these have been destroyed by the floods and cyclones in 1999 and 2010. This led to the scarcity of drinking water in the area and many people living in taluka which has about 200 islands also migrated from the area.

  The Chloride level in the sampled water has been higher as compared to the National Standard for Drinking Water Quality. Chloride in drinking water may have come from the saline intrusion. The turbidity is also very high *i.e.* 81 NTU

as compared to the prescribed standard of 5 NTU. The water has hardness concentration of 1000.4 mg/l which means is higher than the standard limit.

The microbiological analysis of the sample shows the presence of Faecal coliform which is harmful for human health. The presence of these bacteria in water may cause water borne diseases like dysentery, gastroenteritis, typhoid fever and hepatitis A. The presence of the bacteria in water indicates a higher risk of pathogens being present in water. The water is microbiologically unsatisfactory for human consumption.

- **Nara Wetland Complex**
  The water quality in area is generally sweet. Total dissolved solids (TDS) lies between 500 to 800 ppm. There are also brackish lakes and TDS varies from 10,000 to 28,000 due to less recharge. The ground water quality is dominated by Sulfate, Cl and Ca Mg ions (Halcrow 2002). The TDS (or conductivity) is important parameter along with pH in determining the water quality. The value of both is acceptable in freshwater lakes while it is otherwise in saline lakes.

  The turbidity is higher and above the WHO standard of 5 NTU. The higher turbidity may be due to the waste discharge and/or agriculture run off.

  Nara canal originates from River Indus. The Indus water is generally contaminated carrying organic and inorganic pollution load from upstream human activities. The Sindh Environmental Protection Agency (SEPA 2002) reported that the Indus River BOD is over 6.5 mg/l, which according to Global Environmental Monitoring System (GEMS) classification puts this river as highly polluted.

  The microbiological analysis of water of the two sites confirmed the presence of Fecal coliform. The water containing Fecal coliform is harmful for human consumption as this may cause water borne disease. The presence of Fecal coliform in fresh water bodies is an indicator of contamination with human and animal excreta.

4.5.1.2 Agriculture

- **Manchhar Lake**
  The water of Manchar lake was predominantly used for agriculture. The degradation of the lake including increase in salinity has affected the crops. The salinity of water is related to conductivity. The salty water has greater conductivity. The water was not analysed as per guidelines for agriculture purpose.

- **Kharochann**

The water analysis of water was done as per national standards for drinking water quality and analysis does not reflect the acceptable standard for agriculture. The TDS was not measured.

- **Nara Wetland Complex**

4.5.1.3 Fisheries

Water quality parameters were only taken to determine the quality of water for drinking purpose. However, it has been noted that the population of 100,000 fishermen who were directly linked with fishing occupation have suffered in recent years. Increased inflow of saline effluent has resulted in the devastation of the lake.

Table – Water quality parameters over site

Parameters	Manchhar Lake	Kharochann	Nara Wetland Complex
pH	7.76 – 7.92	7.70	8.06 – 8.58
Chloride	733.6 mg/l – 931.5 mg/l	2678 mg/l	26.2 mg/l – 153.7 mg/l
Conductivity	2908 µS – 4070 µS	9310 µS	316 µS – 1652 µS
Turbidity	14 NTU – 33 NTU	81 NTU	10 NTU – 16 NTU
Total Hardness	733.6 mg/l – 931mg/l	1000.4 mg/l	153.9 mg/l – 378.3 mg/l
Total Alkanity	136.3 mg/l – 160 mg/l	106.7 mg/l	118.3 mg/l – 525 mg/l
Cr (Hexa)	0.01 mg/l – 0.05 mg/l	0.01 mg/l	0.02 mg/l
Lead	BDL	BDL	BDL
Zn	BDL	BDL	BDL
COD	58 mg/l – 106 mg/l	18	BDL
Iron	BDL	BDL	BDL
As	0.025 mg/l – 0.1mg/l	BDL	BDL

BDL = Below detection limit

Table – Microbiological Parameters over site

Parameter	Manchhar Lake	Kharochann	Nara Wetland Complex
Faecal coliform	64 cfu/100 ml – 148 cfu/100 ml	64 cfu/100 ml	83 cfu/100 ml – 250 cfu/100 ml

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