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Detailed Ecological Assessment of Fauna, including Limnology Studies at Chotiari Reservoir

2007 - 2008

JE MAINTIENDRAI

Indus For All Programme
WWF - Pakistan

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List of Acronyms

A	Abundant
As	Arsenic
BOD	Biochemical Oxygen Demand
C	Capture
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
CMR	Capture-mark-recapture
Cr	Chromium
DD	Data Deficient
DO	Dissolved Oxygen
DR	Diurnal
E	Endangered
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EIAO	Environmental Impact Assessment Ordinance
EMMP	Environmental Management and Monitoring Plan of Chotiari
FAO	Food and Agriculture Organization.
GEMS	Global Environmental Monitoring System
GIS	Global Information System
GPS	Global Positioning Stationing
GRN	Grainivore
ha	Hectare
HRB	Herbivore
ID	Index of Density
IDER	Indus Delta Ecoregion
IEP	Indus Eco-region Programme
IFAP	Indus For All Programme
INS	Insectivore
IUCN	The World Conservation Union
KB	Kalri Baghar
KTS	Keti Shah
LBOD	Left Bank Outfall Drain
LC	Less common
LC	Least Concern
M	Meters
m	Meters
MAF	Million Acre Feet
Mg	Magnesium
Mm	Millimeters
mm	Millimeters
NC	Nocturnal
NC	Nocturnal
NGO	Non Government Organization
Ni	Nickel
No.	Number

NR	Natural Resources
NT	Near Threatened
NTU	Nephlometric Turbidity Units
NWFP	North West Frontier Province
P	Protected
Pb	Lead
PF	Pai Forest
PMNH	Pakistan Museum of Natural History
ppt	particles per thousand
R	Rare
RBOD	Right Bank Outfall Drain
RD	Reduced Distance
RD	Reduced Distance
RNE	Royal Netherlands Embassy
S	Sighting
SEPA	Sindh Environmental Protection Agency
SFD	Sindh Forest Department
SO4	Sulphate
SVL	Snout to Vent Length
SWD	Sindh Wildlife Department
T	Trapping
TSS	Total Suspended Solids
TDS	Total Dissolved Solids
TMDLs	Total maximum daily loads
UMBS	University Marine Biological Station
UNEP	United Nations Environment Programme
viz.	Videlicet; namely
VU	Vulnerable
WAPDA	Water and Power Development Authority
WHO	World Health Organization
WQ	Water Quality
WWF-P	World Wide Fund for Nature – Pakistan

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Physicochemical study of water	Dr. Bakshal Lashari and Dr Abdul Khalique Ansari

Acknowledgements
The completion of this detailed ecological assessment was the effort of a number of individuals who are experts in their field. The following people up the teams that made this exercise possible:

Waseem Ahmad Khan, Syed Hasnain Ali Dr. Mohammad Rafique, Ataullah Pandrani Shamim Fakhri, Dr. Rafaqat Masroor, Syed Ghalib, Rafiq Rajput Dr. Makhdoom Hussain, Zakia Khatoon, Dr. Mohammad Rafique, Dr. M.K. Laghari, Ahsan Feroze, Dr. Bakshal Lashari and Dr. Abdul Khalique Ansari

Review of technical reports was carried out by the following:

Dr. Abdul Aleem Chaudhry, Muhammad Moazzam Khan, Dr. Wazir Balouch, Dr. Shahid Amjad.

The Programme would also like to thanks the staff of Sindh Wildlife Department, Sindh Forest Department, Sindh Livestock and Fisheries Department for their support in carryout these studies. Thanks must also go to the Site Manager and NRM Officer at Keenjhar Lake for their valuable input. Indus for All Programme greatly appreciates the efforts, commitments and passion of these professionals for their contribution in establishing this assessment

The programme also appreciates the efforts of Farooq Laghari Mustafa Abbasi, Meherunissa Hamid and Nida Shams for their input in editing map development and graphic designing.

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Karachi - June 2008

EXECUTIVE SUMMARY

The 'Detailed Ecological Assessment Study Report' by the Indus for All Programme provides extensive and updated (April 2008) status of various ecological aspects of the Programme's four priority sites. These include a summer survey (June to July) and winter survey (November to February) of vegetation, reptiles and amphibians, avi-fauna, mammals (which have been divided into large and small), fisheries (divided into freshwater and marine) water-quality and limnology which includes phytoplankton, zooplankton and physicochemical properties of the water at the programme sites. The floral aspects of the study is available in a separate report titles

To ensure the authenticity of the reports, maintain the level of scientific approach and install a sense of ownership at government level, a large proportion of the consultancy's were outsourced to Pakistan Natural History Museum, Zoological Survey of Pakistan, Mehran University of Engineering and Technology, University of Karachi and University of Sindh.

This detailed ecological assessment is planned under of the completion of Programme Output A.1.2.1 – Detailed ecological assessment of Chotiari Reservoir.

Chotiari Reservoir: Chotiari Reservoir lies in the province of Sindh, on western flanks of Achro Thar desert (white sandy desert) at about 30 - 35 km northeast of Sanghar City. The Reservoir occupies an area of about 18,000 hectares and has water storage capacity of 0.75 Million Acre Feet (MAF) flooding an area of approximately 160 km^2.

Chotiari reservoir is created in a natural depression that exists along the left bank of the Nara canal. The depression area is bounded by sand hills towards north, east and south-east, while towards the west and south lies the Nara canal.

This reservoir is established to improve the irrigation supplies during lean months when Indus flows are at minimum. It is an off canal storage reservoir retaining Indus flood water collected during the peak flow period (June to September) and releasing it for use during the dry season (mid October to mid April). This reservoir will be filled from the Nara canal through a 6,500-cusec capacity channel, the Ranto Canal, off-taking from the Nara Canal at Jamrao Head.

The reservoir land area lies within seven dehs (cluster of villages) viz. Makhi, Haranthari, Bakar, Akanvari, Khadvari and Phuleli. The aquatic features of the reservoir area comprise diversity of small and large size freshwater and brackish Lakes, smallest being of 1 Hectare area and largest of about 200 Hectares which occupy about 30% of the total reservoir area. These Lakes are a source of subsistence and commercial fisheries for the local people.

The area has a hot arid climate. The hottest months are May and June when average maximum daily temperature exceeds 40°C. The coolest months are December to February, when the maximum daily temperatures range from 25 to 30°C. Rainfall is sparse and erratic and is most frequent between July and August when it averages 40 mm monthly. Annual average rainfall is about 125 mm. Floods are common in monsoon season. Evaporation averages 11 mm per day in summer, falling to 2.5 mm per day in winter. Annual average evaporation is about 2250 mm. The local population is engaged in fishing, agriculture, jobs in

different sectors and livestock rearing. A large area is being used for livestock grazing, which is a major occupation for the local communities. According to one estimate, nearly 400 families are associated with livestock rearing in the reservoir area. The majority of livestock includes, buffalo, cattle, goat, sheep and camel. A variety of non-timber forest produce that grow naturally in the reservoir area are used by local people for hut making, mat making, sweep sticks, roof thatching, medicinal and food purposes. Women living in those areas where reeds are abundant are associated with mat making as a source of their livelihood. Socio-economic assessment study conducted by Indus for All programme revealed that varying proportions of households of Chotiari Wetland Complex have access to different natural resources such as irrigation water (35%), drinking water (66%), fish (56%), fuel wood (70%) and grazing of livestock (36%). It was also found that on an overall basis, 48% of respondents agreed that irrigation water resources have depleted during the last five years. Over 70% of respondents agreed that the fisheries have declined, while 64% agreed that forest resources have sharply depleted during the last 5 years.

Large mammals: Spending eight days in the field (four days during summer survey in June 2007 and another four days during winter survey in January 2008) a total of 58 animals of 14 different species, belonging to three orders (Carnivora, Artiodactyla and Perissodactyla) were recorded from the study area. Out of 14 recorded species of large mammals, eight were observed directly while six mammals were recorded on the basis of indirect evidences like tracks, faeces and interviews of locals and wildlife watchers from Sindh Wildlife Department. Out of the 14 recorded species, one is Critically Endangered (CE), two are Vulnerable (VU), five Near Threatened (NT), four Least Concern (LC) and one Data Deficient (DD) according to the IUCN Red List of Pakistan Mammals 2005 while the status of feral donkey is not known. Jungle cat and small Indian mongoose are enlisted as Least Concern (LC) while fishing cat as Vulnerable (VU) in IUCN international Red List 2006. Caracal, Jungle cat, Fishing cat, Indian desert cat, Indian otter, Hog deer and Chinkara are protected (P) in Sindh. Jungle cat, Fishing cat and Indian desert cat are listed in Appendix II while Caracal and Hog deer in Appendix I of the CITES Category 2007.

Small mammals: within Chotiari Reservoir area 19 small mammals were recorded belonging to eight families and four orders were recorded. Out of 19 species ten were granivore, two were herbivore, five were insectivore and two were omnivore.

Reptiles and amphibians: The Chotiari Reservoir can be delineated into four distinct habitats viz. Desert scrub, Sand dunes, Riverine forest and the proper Reservoir area and its associated small natural lakes (Dhands), each with its specific flora and fauna. The Riverine forest is dominated by *Populus euphratica, Dalbergia sissoo, Prosopis cineraria, Acacia nilotica* and *Zizyphus mauritiana* while the vegetation in sand dunes and desert scrub includes *Calotropis procera, Capparis decidua, Salvadora oleoides, Crotolaria burhea, Alhaji maurorum* and *Calligonum polygonoides.* Aquatic vegetation of the reservoir comprises of *Typha latifolia, T. angustata, Phragmites karka, Ipomoea aquatica, Nymphaea lotus, Nelumbo nucifera, Polygonum* spp., *Urticularia lotus* and *Saccharum spontaneum.*

Several villages and small islands were surveyed from 17 to 20 June and 14 to 16 November 2007 for the presence of amphibians and reptiles. The outside areas of the reservoir which were surveyed included: Khair Muhammad Junejo, Ali Bakhsh Goth, Bakar Pathan, Jalal, Henro in Sari Lake, Goth Mohammad

Hassan Hingharo, Zero Point, Goth Maula Bakhsh Behan, Makhdoom of Haala area, Muhammad Usman Ibuppoto, Akhanwari pumping station, Paksari, Noon Gharo Lake and Ranto Canal. The islands inside the reservoir were also surveyed to maximize the observation and collection including Saddori Bit, Sabir Jee Darro, Korrki, Phulail, Urs Junejo and Ludhi-waro Dharro. Both day and night surveys were conducted in four of the delineated habitats of the reservoir and all possible methods were employed to collect amphibians and reptiles.

At one site, RD-174 or D-8, the area is perhaps a representative habitat of sand dunes, which is more suitable for the pitfall traps. The author, therefore, installed pitfall trap (N 26° 07′ .234″, E 69° 08′ .657″) for three days in the summer season. This method proved to be the most successful and a large number of lizards and some colubrid snakes were collected. Due to the beginning of hibernation period of the amphibians and reptiles, there are minimal activities during winter; hence the pitfall traps were not placed in November surveys.

Chotiari reservoir has a great significance pertaining to the natural history of herpeto-fauna. There is a handsome natural population of Marsh Crocodile (*Crocodylus palustris*) in the Nara Canal and other sites inside Chotiari reservoir (Hafeez, 2006) area. Chotiari reservoir with the population of crocodiles as reported by Hafeez (2006) could possibly prove to be one of the largest reservoirs of crocodiles in Pakistan. The presence of Rock Python (*Python molurus*) is also suggestive of the importance of this reservoir. The Rock Python is not only reported by the earlier herpetologists but also the local inhabitants claim for its definite presence. The status, distribution and other details of these two key species of reptiles are discussed in detail in the species account section. Though, the author did not observed rock python in both the summer and winter studies, yet there is a need of consistent monitoring of the area for this species. During the winter studies, though the activities of the herpetiles were not highly evident, yet a large number of herpetiles were observed and collected.

The summer studies resulted into the collection/confirmation of 28 species of amphibians and reptiles out of 58 species possibly occurring in the area (28 species being observed or collected by the author and his team and the remaining were identified by the local inhabitants after thorough discussion as well as by earlier literature citations). In the winter studies, more areas were surveyed, which resulted in the observation and collection of 3 additional species i.e. two species of freshwater turtles i.e. *Kachuga tecta* and *Lissemys punctata andersoni* and a lacertid *Mesalina watsonana*, thus making the total number of herpetiles as 31. The amphibians are represented by 3 species belonging to 3 genera and 2 families. Among the reptiles, chelonians are represented by 9 species belonging to 7 genera and 3 families. A single species of Marsh Crocodile belonging to family crocodylidae is also present. Lizards are the second dominant group of herpetiles in the study area, represented by 20 species belonging to 15 genera and 7 families. Snakes outnumber all the groups of reptiles and are represented by 25 species belonging to 18 genera and 6 families.

Birds: Chotiari Reservoir has diverse habitats for birds, which include lakes (Chotiari Reservoir), swamps, marshes, reed beds (having somewhat dense vegetation cover), irrigation canals, riverine forest, cultivated land and desert/semi-desert area. The area provides suitable habitat for a wide variety of birds. As many as 109 species of birds have been recorded from the area (Ghalib et al 1999). The summer surveys of birds were undertaken from in August 2007 and WHAT 2008 during which 80 species of birds were recorded in the summer surveys while 78 species were recorded in the winter surveys. There were a certain species of birds of particular importance viz. Marbled Teal, Sind Babbler,

Pallas's Fishing Eagle, White-backed Vulture, Saker Falcon, Partridges, Watercock, Wood Sandpiper, Knot, Ruff, Painted Snipe and Cliff Swallow observed at Chotiari Reservoir.

Freshwater fisheries: During the survey of Chotiari Reservoir a total of 47 species of fish were recorded from 9 Orders and 14 families. Among the 47 species recorded so far from the Chotiari reservoir, 13 specis viz., *Cirrhinus mrigala, Gibelion catla, Labeo calbasu, Labeo dyocheilus pakistanicus, Labeo gonius, Labeo rohita, Cyprinus carpio, Sperata sarwari, Rita rita, Bagarius bagarius, Wallago attu, Clupisoma garua, Eutropiichthys vacha* and *Oreochromis mossambicus* are highly commercially important. Among them *Cirrhinus reba, Cirrhinus mrigala, Gibelion catla Labeo calbasu, Labeo dyocheilus pakistanicus, Labeo gonius, Labeo rohita, Cyprinus carpio* are hervivorous while, *Sperata sarwari, Rita rita, Bagarius bagarius, Wallago attu, Clupisoma garua, and Eutropiichthys vacha* are carnivorous. Four species have fairly high economic importance. Nine species are important for Aquarium purpose. The rest 21 species, though, have less economic important but are an integral part of the ecological system and biodiversity.

A total of 9 Orders were recorded over the 47 species with Cypriniformes (Carps) being the most dominant (22 species) followed by Siluriformes (Catfish) (14 species) and Perciformes (Perch) (5 species). The remaining orders were presented by one or two species only.

Phytoplankton: A total of 85 algal/phytoplankton samples were collected during the summer survey out of which 248 algal species belonging to 96 genera of 9 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta and during the second survey in November 2007 more than 100 samples were collected from Chotiari reservoir dam, out of these a total of 359 algal species belonging to 116 genera of 9 phyla Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta, 80 aquatic plants and 32 fishes along with some physico-chemical parameters were recorded.

Zooplankton: At Chotiari, during the summer survey, the activity of terrestrial invertebrates including the arachnids, Chilopods and certain aquatic invertebrate groups were increased at a greater rate. This is supported by the fact that the rise in temperature results in increase in the activity of animals. This increase in activity may be in response to the greater consumption of oxygen. The enzymatic rates and thus the metabolic activities of the invertebrate body are largely dependant on the temperature increase which may at times increase exponentially with the increase in temperature.

There is no report of prawns in Chotiari Reservoir. The water of the reservoir is mainly lentic and static. The lakebeds consist of sand, silt and mud but the water is very clear. At most of the areas the bottom of the lake is visible even at greater depths. The productivity of the aquatic vegetation is tremendous and islands of dead uprooted large patches of *Saccharum* are found floating at various locations in the lake. The primary productivity is very high. Due to the extension of Nara desert in the proximity of the reservoir, the suburbs of the water-body provide excellent habitat for the terrestrial invertebrates especially the desert dwelling invertebrates. Although the water in the lake comes directly from the Indus through the Nara canal, there is no prawn population in the lake due to the

limnological and hydrological conditions which are different from those at Keenjhar Lake. In Chotiari Reservoir, the micro-invertebrate population is healthier during the summer season as compared to the winter though the insect larvae especially those of the midge flies are more prominent in this lake during winter. This also indicates the high nutrient supply to the reservoir during summer. A few Solifugids and Araneae were captured from the vicinity of the reservoir. Some Chilopod specimens, which are found in a small population in the surrounding areas of the Chotiari Reservoir were also captured and investigated for their taxonomic status.

Physical and chemical: Chotiari Reservoir is a freshwater lake covering an area of about 18,000 ha and is situated in Sanghar District at a distance of about 30-35 km northeast of Sanghar City. The reservoir exhibits a complex of terrestrial and aquatic ecosystems. The aquatic features of the reservoir area comprise of diverse small and large size (1-200 ha) fresh and brackish water lakes. These lakes are a source of subsistence and commercial fisheries for the local people and habitat for crocodiles, otters, fresh water turtles and feeding and nesting grounds for a variety of resident and migratory birds.

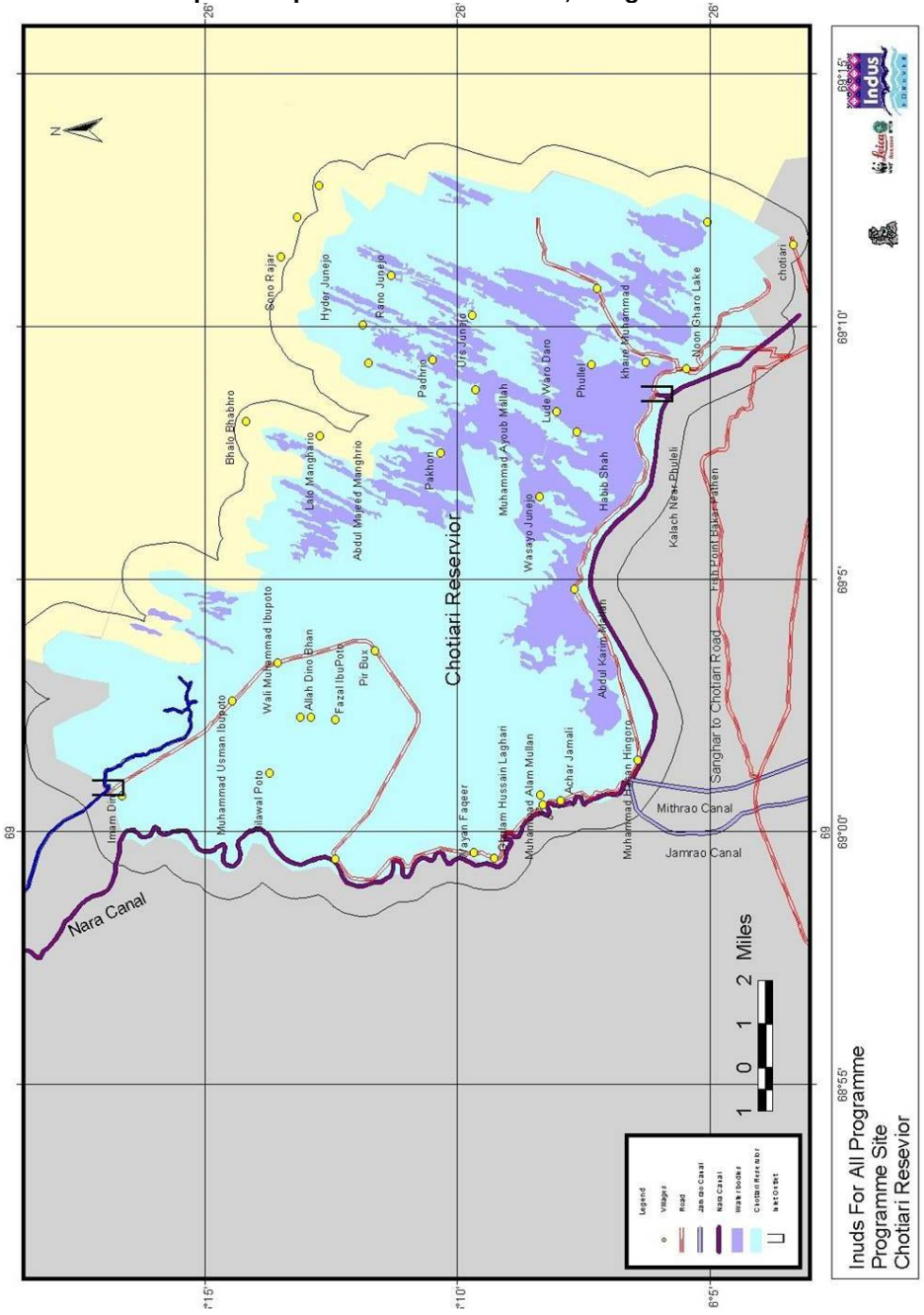
The reservoir receives fresh water regularly from the Indus River through Raunto canal off taking from main Nara Canal. The pond level of the reservoir is varying from time to time which rises/falls from about 6 m to 3 m. The reservoir is feeding source of many livelihoods including irrigated agriculture, fishing, drinking and migratory birds. The rain water in the area is also very erratic which varies from 0.16 to 21 inches annually.

Under the Left Bank Outfall Drain (LBOD) Project, the reservoir capacity was increased and that has now created huge seepage problem to the surrounding area of the reservoir. Consequently, the fertile agriculture land has converted into water logging and salinity area, and affecting the livelihood of the irrigated agriculture populace. Bakar Lake which was part of this reservoir has also been cut off from the reservoir which does not receive fresh water and as a result water quality of the lake is deteriorating. The water quality of seepage water which is being pumped back in to the reservoir is saline water though it is not making any big change in the main reservoir water but in future it could cause a serious problem for the natural resources of the reservoir and livelihood of the surrounding local community.

Chapter 1: Introduction

1.1 Introduction to Chotiari Reservoir

Map 1 – Map of Chotiari Reservoir, Sanghar District



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1.1.1 State of biodiversity

Chotiari is a rich ecological site and a unique habitat consisting of wetland, riverine forest, desert scrub and sand dunes. This area is formed from several small natural Lakes (dhands) and inter-dune depressions that protrude finger-like into the western margins of the Thar Desert. Depth of water in the Lakes ranges from shallow (less than 6 feet) to deep (30 to 45 feet). The edges of the Lakes present a mosaic of reed beds, which lie alongside alluvial fans, irrigation channels, riverine forests, desert dunes, swamps and agricultural land. Historically, the Chotiari reservoirWetland Complex was flanked by "Makhi forest" famous for rich reserves of quality honey. Most of this forest was cleared and converted into agriculture fields in the British era in the backdrop of "Hur Revolt".

- **Flora:** Aquatic vegetation includes *Typha latifolia, Typha dominghensis, Phragmites karka, Ipomoea aquatica, Nymphaea lotus, Nelumbo nucifera, Polygonum* spp. The Riverine Forest has canopy of *Populus euphratica, Dalbergia sisso, Prosopis cineraria, Acacia nilotica* and *Zizyphus mauritiana* etc. Leghari *et al.* (1999) reported 41 aquatic plants including two bryophytes (*Riccia spp.*), Four Pteridophytes and 35 Angiosperms. They also reported 157 species of algae.

  Cultivated crops are generally cotton (Kharif season) and wheat (Rabi season), augmented with rice, sugar cane, animal fodder and vegetables. A further detail of cultivated herbs and shrubs on agricultural lands and in habitations could be seen from **Table 1** below.

Table 1 – Cultivated plant species recorded at Chotiari Reservoir

S.no	Family	Plant species	Life form	Habit
1	Anacardiaceae	*Mangifera indica* L.	Phanerophyte	Tree
2	Boraginaceae	*Cordia myxa* L.	Phanerophyte	Tree
3	Caesalpinaceae	*Parkinsonia aculeata* L.	Phanerophyte	Tree
4	Caesalpiniaceae	*Tamarindus indica* L.	Phanerophyte	Tree
5	Euphorbiaceae	*Ricinus communis* L.	Phanerophyte	Small tree
6	Fabaceae	*Cyamopsis tetragonoloba* (L.) Taub.	Therophyte	Herb
7	Fabaceae	*Sesbania bispinosa* (Jacq.) W.F. Wight	Chamaephyte	Shrub
8	Lythraceae	*Lawsonia inermis* L.	Phanerophyte	Shrub
9	Meliaceae	*Azadirachta indica* A.Juss.	Phanerophyte	Tree
10	Mimosaceae	*Albizzia lebbeck* (L.) Benth.	Phnerophyte	Tree
11	Mimosaceae	*Pithecellobium dulce* (Willd.)Benth.	Phanerophyte	Tree
12	Moraceae	*Ficus religiosa* L.	Phanerophyte	Tree
13	Myrtaceae	*Conocarpus erectus*	Phanerophyte	Tree
14	Myrtaceae	*Eucalyptus camaldulensis*	Phanerophyte	Tree
15	Papilionaceae	*Dalbergia sissoo* Roxb.	Phanerophyte	Tree
16	Pedaliaceae	*Sesamum indicum* L.	Therophyte	Herb

- **Fauna:** The open wetlands and terrestrial areas are habitats for variety of fish, mammals, birds and reptiles.

- **Fish:** Chotiari Reservoir is now producing fish weighing about 525 tonnes per year. In 1997 Sindh University conducted a study of fish fauna and recorded 31 fresh water species;

- **Mammals:** Hog Deer, Chinkara, Jungle Cat, Fishing Cat, Caracal, Smooth coated Otter, Wild boar, Mongoose, Desert hare and Squirrels are reported in the area. A survey of Hog deer during the period May – October 1997 estimated that about 90 animals live along the western side of reservoir from Makhi Weir to Akanwari Deh. The gradual decline in vegetative cover has resulted in degradation of natural habitat of the Hog Deer whose wild population has declined severely;

- **Birds:** Chotiari Lakes are important habitat for a variety of bird species. As many as 107 species of birds have been recorded from the area. Two species of birds found in the area are worth mentioning. The Marbled Teal is globally threatened but significant population has been reported to winter and breed here. Sindh Warbler is a rare species that have been reported from this area. The area was significant for migratory water birds. In a survey in 1993, 40,000 birds were observed in this area;

- **Reptiles:** About 50 marsh crocodiles were recorded in Makhi area in 1997. Python, a vulnerable species is also known to occur in the area but its present status is unknown. Varieties of snakes and lizards are found here.

1.1.2 Socio-economic status

Sanghar district came into existence in 1953. Since 1990, it comprises of the following sub-districts (Talukas): Sanghar, Shahdadpur, Tando Adam, Khipro, Jam nawaz Ali and Sinjhoro. It has 55 union councils. Geographically, it is surrounded by Khairpur and Nawabshah districts in the north, Umerkot and Mirpurkas districts in the south, Matiari district in the west and the Jodhpur state of India in the east. The district Sanghar is divided into two broad parts, a green belt in the West and Desert in the East. The main Nara Canal is dividing line of the two parts. The desert comprises on sandy dunes in the eastern part of Sanghar and Khipro Talukas. The desert portion stretches over 1/3rd area of the entire district, which depends on rain, while remaining area is irrigated by Sukkur barrage/Nara Canal.

The main caste groups in Sanghar district are Nizamani, Laghari, Sanjrani, Rind, Chaneeho, Mangrio, Mallah, Kumbhar, Khaskheli, Mari, Wassan and Behan. A substantial number of ethnic Punjabis are also settled in the district. In addition, the scheduled castes such as Kohlis, Bheels, and Meghwars also work as agricultural labor/ tenants in Sanghar district.

- **Educational Institutions**
  In the field of education a sufficient number of institutions are functioning to improve the condition of masses in the district:

  - Degree colleges 07
  - High Schools 51
  - Middle Schools 48

- Primary Schools 1026
- Mosque Schools 1016

- **Livelihood Sources**
  Livestock is the main occupation in the desert area of district Sanghar which is known as "White Desert" or "Achhro Thar". A vast tract of Sanghar district comprises of irrigated agricultural land. Industries also play a vital role in the economy of Sanghar district. There are Cotton Ginning factories in all talukas of Sanghar. In Tando Adam, there are Textile mills, Food Industries and Match Industries.

- **Irrigation and Drainage**
  Nara canal is massive source of water in this district. The tributaries of Nara canal include Khipro Canal, Jamraoo Canal and Mithrao canal. Participatory irrigation management is being practiced on Nara canal through 196 Farmers' Organizations (FOs) and the Nara Canal Area Water Board (NCAWB). Members of these organizations have received training in project management and networking for productivity enhancement. Sanghar district was a component in the LBOD Stage- I project. It has a vast network of surface drains and drainage tube wells connected with the spinal drain.

- **Piri Muridi and social stratification**
  The religious institution of *piri muridi* is very strong in Sanghar district. Followers of Pir Sahib Pagara are in majority throughout the district. In addition, due to large landed estates, social stratification on the basis of land ownership is widespread. The curse of bonded labor is also reported in the district.

- **Major NGOs**
  Two major NGOs having programmes in the environment sector are: Sustainable Development Foundation (SDF) and Sindh Agricultural & Forestry Workers Coordination Organization (SAFWCO). Pakistan Fisher Folk Forum (PFF) is quite active on the livelihood issues of the fishing communities. It has a chapter in Phulail village of the Chotiari reservoir site. Shirkat Gah has also worked here in the past on the issue of Chotiari Reservoir. There are several NGOs in the health sector including Marie Stopes Society and the HANDS.

1.2 Rationale and objectives

1.2.1 Large Mammals Survey

1.2.1.1 Rationale

The Indus Eco-region is one of the forty biologically richest eco-regions in the world, as identified by WWF. The Indus Eco-region Programme (IEP) is a 50 years long (2005 - 2055) initiative of WWF - Pakistan and the Government of Sindh that will address poverty and natural resource degradation in the Indus eco-region. In the Biodiversity Visioning and Eco-region Conservation Planning Workshop for the Indus Eco-region, held in Karachi in July 2004, participants identified fifteen prioritized areas within the Indus eco-region (WWF – P 2008). An *Indus for All Programme* of the IEP has been implemented on five out of fifteen prioritized landscapes with support from Royal Netherlands Embassy (RNE) in July 2006 for a period of six years. The five sites are Keti Bunder (coastal), Keenjhar Lake (fresh water ecosystem), Pai Forest (irrigated forest), Chotiari

Reservoir (desert ecosystem) and Keti Shah Forest (riverine forest). 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 nexus.

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

As a part of the detailed ecological assessments and to study the mammalian fauna of the project sites, the study sites were visited twice; firstly during summer in June 2007 and secondly in winter during January 2008. Each visit of all the five sites was of 3-5 days duration.

1.2.1.2 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.

1.2.2 Small 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 the 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 in 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 sagebrush 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 plant 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 faeces 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 that 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 the 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 large numbers of insect larvae by shrews has been reported by Buckner (1964). 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 foxes (*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 (McInvaille and Keith, 1974). Further, population outbreaks of small mammals can induce predators to switch from preferred prey, thus reducing predation on some game species.

1.2.2.2 Objectives of the study:

a. To provide a detailed ecological assessment and systematic account of small mammal of the programme sites and their buffer zones.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas;

c. Collect and review secondary data on the small mammal species of the study sites, using the available literature and knowledge of local inhabitants.
d. Prepare a taxonomical checklist of all the species with their English and local names and their status in the study sites.
e. Identify threatened mammalian species in the Indus for All Programme, WWF Pakistan sites and recommend conservation measures;
f. Study the behaviour of various species of rodents and other associated groups in relation to habitat and diet in the study sites.
g. Assessment of impacts of environmental changes and human population pressure on potential mammalian species and their habitats. Associated mitigation steps are also to be suggested.
h. Provide photographs, where possible, of the small mammal species.
i. Compile a report on the consultancy addressing all the above-mentioned issues.
j. To identify the key species of small mammals inhabiting the area.
k. To identify impact of small mammals on the overall livelihood of the people.

1.2.3 Reptiles and amphibians survey

1.2.3.1 Rationale

Amphibians and reptiles are very important animals among the vertebrates. Amphibians show the transition from aquatic to terrestrial life. Reptiles, the animals that invaded land, were the first fully terrestrial forms of life. Apart from their impressive evolutionary history, they beautifully 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 the 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 enable us to know about the natural wealth of all the Programme sites in terms of amphibians and reptiles. 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.

1.2.3.2 Objectives of the study:

The study was envisaged to provide for the first time, a comprehensive ecological and systematic account of the amphibians and reptiles of the Programme sites and their buffer zones. The prime objectives of the study were to:

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 the 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 habitats and to suggest associated mitigation measures.
g. Provide photographs, where possible, of the amphibian and reptile species.
h. Compile a report on the consultancy addressing all the above-mentioned issues.

1.2.4 Birds survey

1.2.4.1 Rationale

The species of birds and number of birds of species observed have been recorded during summer and winter. Population studies on the birds of the area were not undertaken because of time constraints. The overall status of each species observed has been given categories such as common, seasonal and rare. It was not possible to predict trends in the population of key species of birds, as it requires at least ten years data.

This consultancy portfolio aims to conduct a series of detailed ecological assessments in order to establish a baseline in and around the four Programme areas plus Keti Shah. The survey will adopt recognized scientific methodologies. The baseline will determine key livelihoods interventions of Indus for All Programme by identifying the gaps and opportunities.

1.2.4.2 Objectives of the study:

a. Conduct a review of literature on bird fauna of the study area.
b. Develop a species inventory of the resident and migratory birds with notes on relative occurrence and distribution of each program area.
c. Conduct a site specific study on main habitats important to bird species including habitats of critical importance.
d. Record program area specific study of human impacts to resident and migratory bird population.
e. Assist the GIS lab in developing GIS based information regarding occurrence and distribution of bird fauna for each Programme area.
f. Document and describe bird species of “Special Concern” with economical and ecological perspective both in resident and migratory avifauna found within each program area.
g. Conduct studies to describe and assess anthropogenic impacts on bird species found in each program area.
h. Record photographs and other information collected and compiled on the avifauna of each Programme area.
i. Submit detailed assessment report for each Programme area.

1.2.5 Freshwater Fisheries
1.2.5.1 Objective

a. Enlist and describe existing resident and migratory fish resources, their abundance, diversity and habitats in the study area
b. Prepare a taxonomical checklist of all the species with their English and local names and their status in the core and buffer zones
c. Help in developing GIS based information regarding occurrence and distribution of fish fauna.
d. Document the anticipated changes to resident and migratory fish population in the study area.
e. Document and describe fish species of "special concern" regarding the economic and ecological perspectives found in the study area
f. Suggest suitable methods of monitoring fish in the core and buffer zones of the study area.
g. Conduct a local survey of the fishermen to assess the trends of fish production for the last ten years.
h. Develop simple indicators for assessing the population trends of the fish that can be applied by the local staff in future.
i. Study the suitability or otherwise of the conventional fish ladders used in barrages and recommend the suitable measures for safe passage of all and critical fish fauna including Blind Indus dolphin.
j. Describe and assess potential anthropogenic impacts on fish species found in the study area
k. Submit a comprehensive baseline reports and monitoring plan to the team Leader.

1.2.6 Phytoplankton
1.2.6.1 Rationale

Qualitative and quantitative determinations of algae is essential for determining the aquatic productivity, as algae is the chief source of food for aquatic animals including the important group of Cryptogamic flora. Some species are excellent whilst others are good producers of food in the food cycle of aquatic ecosystems. Algae is widely distributed and is an important component of various ecosystems like marine, rivers, ponds, streams, dams, lakes etc. Algal flora can also be used as a good indicator of pollution (Patrick & Reimer, 1966).

Algae are among the most important and prime segment of the aquatic environment. The quantity and quality of algal flora is affected by many ecological factors, which influence the diversity of algae directly or indirectly. The main factors determining algal diversity are temperature, availability of nutrients, light, CO_2 and oxygen. In lake in the subtropical region, water temperature plays an important role for the production of algae up to a certain limit. Carbon dioxide is critically important and only those water bodies abundantly supplied by this gas can support sufficient growth of algae. The excess amount of CO_2, however, causes water-blooms which is a growth of algae at or near the surface of a body of water; followed by a series of disturbed biological conditions. Oxygen is one of the primary limiting and determining factors in phytoplankton ecology. Algae produces abundant oxygen during the daytime, which is, consumed both by the fish and by the algae itself. The amount of oxygen produced by algae determines the quantity and kinds of aquatic life which a water body may support at different levels. Light and nutrients also play a direct role for qualitative and quantitative growth of algae. Extraordinary high concentration of nutrients is, however, associated with eutrophication resulting in algal blooms.

It is believed that the first living cell that appeared on planet earth emerged from the ocean. In all its form, life has developed from the growth of mono-cellular algae. About 90% of the species of marine autotrophs are algae and about 50% of the global photosynthesis is algal derived thus every second molecule of oxygen we inhale come from algae and algae reuse every second molecule of carbon dioxide we exhale (Melkinian 1995). The importance of algae and their consumption for human is well known since 300 BC in China and Japan. These two countries are the major algae/sea weed cultivators, producers and consumers in the world such as the Indian Ocean region countries like Malaysia, Indonesia, Singapore, Thailand, and Korea. Algae/sea weeds are used in salad, jelly, soup. In Pakistan algae/sea weeds consumption is negligible so there is need for awareness of algae as a source of health, basic food as they are rich and an easily available source of vitamins, minerals and trace elements.

1.2.6.2 Objectives of the study:

a. Collection and identification of phytoplankton/algal samples using latest techniques.
b. Preservation according to standard method.
c. Document the changes to algae and other aquatic plants in study area.
d. Document and describe algae and other aquatic plants species of “special concern” regarding the economic and ecological perspective found in the study area.
e. Suggest suitable species of algae and other aquatic plants used by fish in study area.
f. To submit a comprehensive baseline reports and monitoring plan.

1.2.7 Zooplankton

1.2.7.1 Rationale

Invertebrates have complicated and imperative roles in maintenance of biotic communities. They are integral to nearly every food chain, either directly, as food for fishes, amphibians, reptiles, birds, mammals, or indirectly, as agents in the continuous recycling of nutrients in the soil. Almost all food webs are dependent on invertebrate species that are performing vital ecological functions such as pollination or seed dispersal. A world without invertebrates would be impoverished and fragile, and ecosystems would collapse. Also the sheer number and mass of invertebrates reflects their enormous ecological impact. Though some invertebrates have a negative impact on humans, either by harming them directly as disease agents or attacking some of their interests, still all adverse effects combined are insignificant compared to their beneficial effects.

Invertebrates have been recognized as sensitive biological indicator species of environmental conditions in rivers and streams. These bio-indicators are increasingly being depended as tools for monitoring health of ecosystems, especially that of wetlands. Aquatic macro-invertebrates comprising annelids, mollusks, crustaceans, arachnids and insects are considered reliable indicators of wetland health. The sensitivity and tolerance of invertebrate species make these organisms an excellent group to provide information on overall wetland condition.

Invertebrates live in a vast range of habitats, from forests and deserts to caves and seabed mud. In oceans and freshwaters they form part of the plankton, which comprise of an immense array of tiny living organisms that drift in the surface currents. Invertebrates are also found in the soil beneath and in the air above our heads. Some use wings to propel but others, particularly the smallest

invertebrates, float on the slightest breeze. These tiny invertebrates form clouds of aerial plankton that drift unseen through the skies. (Hawking, J.H et al 2006)

Aquatic invertebrates are an important source of food for birds, mammals, amphibians, reptiles, fish, and other invertebrates. Changes in terrestrial and aquatic habitats lead to changes in invertebrate assemblages, which in turn increase, decrease, or change food supplies for other animals. As impacts occur in a stream, species richness (number of species) decreases but the population size of some species may increase. Further, large-sized species are usually replaced by small species (e.g., Wallace and Gurtz 1986). Conversely, when the stream condition improves, larger invertebrate species replace small species (Grubaugh and Wallace 1995). Such changes can have critical impacts on species that depend on invertebrates for a food supply.

Aquatic benthic invertebrates are a diverse group of relatively long-lived sedimentary species that often react robustly and mostly predictable due to human disturbance of aquatic systems. This capability to demonstrate a strong reaction makes them a cost-effective and comprehensive tool for the monitoring of stream water quality. Benthic invertebrates are therefore among the most common group of organisms used to assess water quality in a good number of wetlands worldwide.

A taxonomic investigation of aquatic invertebrates is essential to assess the status of biodiversity in any area. Monitoring of invertebrates at a higher taxonomic level (genus, family, order) can be useful in indicating changes in invertebrate assemblages in response to some impact if proper controls are established, but such monitoring usually cannot determine loss of species.

The Indus Delta comprises more than of 95% of the total mangrove areas of Pakistan and has the seventh largest mangrove forest in the world. This area has been famous for its mangrove forests and some 129,000 hectares of mangrove. These mangrove forests form a habitat of a large number of migratory and residential bird species and serve as a huge nursery of various fish species. Keti Bunder is part of the Indus delta and is located in the mouth opening of the Indus in the Province of Sindh, Pakistan. It consists of main River Indus, various creeks, estuaries, mud, sand, salt flats, mangrove habitat, marshes, riverine forests, fresh and salt-water lakes, riverbanks and channels. It falls under largely arid and semi-arid climatic conditions and is characterized by river discharge and moderate tides. Mangroves cover in the Delta has decreased by about 70% over the last thirty years (although recently stabilized), which must be reflected in the declining stocks of key coastal/marine species, which are also over hunted, in any case, especially prawn.

1.2.7.2 Objectives of the study

The study was formulated to provide a comprehensive ecological and systematic account of the Invertebrate fauna of Keti Bunder, Keenjhar Lake, Chotiari Reservoir, Pai forest and Keti Shah. The prime objectives of the study were to:

a. Collect and review secondary data on the invertebrates of the above-mentioned area, with the help of available literature and local community.
b. Collect data from the field on species occurrence, abundance and diversity in the study areas.
c. Prepare a taxonomical checklist of the invertebrate groups found in the desired reservoir

d. Study the ecology and behavior of various groups of invertebrates with special reference to crustacean fauna of the desired area (if any)

e. Assessment of impacts from environmental changes and human population pressure on economically important invertebrates and their habitats.

f. Provide photographs, where possible, of the impetrative invertebrate species collected from inside and around the Reservoir.

g. Compile a report addressing all the above-mentioned issues.

1.2.8 Physicochemical properties of water

1.2.8.1 Objectives of the study:

a. Review and compile baseline surface hydrological conditions, baseline ground water conditions, baseline of water quality levels in the Programme area;
b. Study seasonal flow patterns (pre and post monsoon) for each site
c. Collect accurate field measurements for pH, Zinc, TDS, Ammonia, DO, Cyanide, B.O.D, Nitrate, C.O.D, NH_4N_2, oil and grease, conductivity of Phenolic compounds, light transparency/turbidity, total Coli forms, CO_2, Fecal E.Coli, hardness, fecal Enterococci /Streptococci, Ca^{++} Mg, Phosphate, Chlorides, Arsenic, temperature and alkalinity according to approved procedures;
d. Analyze 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.

1.3 Literature Review

1.3.1. Large Mammals

The mammalian fauna, particularly the species of large mammals have always been of interest to wildlife managers and researchers alike. Ellerman and Scot (1951), Ellerman (1961) and Prater (1965) in their publication referred to the species found in Pakistan. Siddiqui (1969) published a booklet on the Fauna of Pakistan that included the Mammalian species. Ahmad and Ghalib (1975) published a Checklist of Mammals of Pakistan. Ahmad and Khanam (1986) published a booklet on the Ungulates of Pakistan, in Urdu language. Ahmed (1997) dealt with the distribution and status of ungulates in Pakistan. Roberts (1997) provided a comprehensive detail on mammals of Pakistan.

The creeks in Keti Bunder are a part of the North Arabian Sea and lies within the Indian Ocean Sanctuary, set up by the International Whaling Commission to protect cetacean population. Information on marine cetaceans along Pakistan coast is very sparse and very little data has been published. Ahmed & Ghalib (1975) reported occurrence of nine mammalian species. Roberts (1997) lists thirteen species of marine cetaceans from coastal waters of Pakistan based on personal communications with different people on sightings. Further evidence suggests that there is an undocumented high diversity of cetaceans in Pakistani waters. There has been no comprehensive survey of cetaceans in Pakistan and only recently University Marine Biological Station (UMBS), University of London, Millport, U.K. in partnership with WWF – P and Centre of Excellence in Marine Biology (CEMB); University of Karachi started cetacean surveys on Pakistan coast and offshore. WWF Pakistan is undertaking surveys of dolphins and

porpoise in Korangi – Phitti creek system in Karachi with support from the Ocean Park Conservation Foundation.

No study on terrestrial mammals has been undertaken in the area. Roberts (1997), Ahmad and Ghalib (1978) have worked on the distribution and status of mammals in Pakistan but did not mention particular occurrence in Keti Bunder area. Ahmad et al (1988) worked on the vertebrate fauna of mangrove swamps of Sindh and recorded 5 species of mammals, including marine and terrestrial mammal but they did not describe the mammals occurring exclusively in the nearby terrestrial area of mangrove forests.

No researchers or wildlife managers have exceptionally dealt with the mammalian fauna of Chotiari Reservoir or its environs. However, WAPDA carried out an Environmental Impact Assessment of the area through Consultants in 1992 (EIA Report 1993). Later, they also conducted studies for Environmental Management and Monitoring Plan of Chotiari reservoir through Consultants MMP – NESPAK – ACE in 1997 (EMMP Report 1998). These studies made a situation analysis of the wildlife including mammals in Chotiari reservoir area. Azam (2002) gave distribution and population Hog Deer in Sanghar district.

A number of workers have studied the fauna of Indus River. Ahmad and Ghalib (1978) gave the distribution of the Mammals of Pakistan including mammals found in the Indus River. Pilleri (1970, 1977), Niazi and Azam (1988), Reeves and Chaudhry (1998), Bhaagat (1999) and Braulik (2006) studied the distribution, population and status of Indus dolphin. However, no work has been done on the mammalian fauna of riverine forest of Keti Shah and the present surveys are the first efforts to study the mammalian fauna of the forest.

1.3.2 Small Mammals

There are several reports on the study of small mammals of Pakistan (Ahmad and Ghalib, 1979; Akhtar, 1958-60; Anthony, 1950; Baig et al, 1986; Banerji, 1955; Beg, et al., 1975, 1986; Frantz, 1973; Fulk et al., 1981; Mehmood et al., 1986; Mian, 1986; Mirza, 1969; Parrack, 1966; Roberts, 1972, 1973; Siddiqui, 1970; Thomas, 1920a,b,1923; Wagle, 1927; Walton, 1973 and Wroughton, 1911,1920) but the most comprehensive and consolidate work is that of Roberts (1997). Roberts (1997) compiled all the information available on the mammalian fauna of Pakistan. After that Woods *et al*. (1997 a, b) gave a detailed account on the small mammals of Pakistan but their work was restricted to the northern mountain region of Pakistan. None of these studies has specifically addressed the mammals of lower Sindh.

The role of small mammals has not been properly studied in Pakistan but it has been a subject of special concern all over the world. Effect of small mammals on vegetation pattern has been studied by Migula et al. (1970), French et al. (1976), Harris (1971), Turner (1969), Fogel and Trappe (1978), Gross (1969), Golley et al. (1975) and Zlotin and Kodashova (1974). Their affect on soil composition and chemistry has been highlighted by Abaturov (1968), Hole (1981) and Zlotin and Kodashova (1974). Small mammals have a very strong interaction with the other animals of the ecosystem and the interactions between small mammals and other animal have been studied by French et al. (1976), Hayward and Phillipson (1979), Buckner (1964), Southern (1970), Clark (1972), Egoscue (1975) and McInvaille and Keith (1974).

1.3.3 Reptiles and amphibians

The herpeto-fauna of Indus for All Programme, WWF Pakistan areas was little studied by early herpetologists (Murray, 1884, 1886; Boulenger, 1890, 1920; Smith, 1933, 1935, 1943; Minton, 1966; Mertens, 1969; Dubois & Khan, 1979; Khan, 1979, 1980). Comprehensive studies have not been undertaken and herpeto-fauna remains marginally explored. This is because the areas are very wide, extremely difficult with very limited infrastructure and other facilities. The conditions were even worse in the past and did not encourage the scientists to venture for studies. Amphibians and reptiles are cold-blooded animals and therefore are more sensitive to the environmental conditions as compared to birds and mammals. However, in the recent past, Khan (1989, 1992, 1993, 1997, 1998, 2006), Baig (1988 a, b, c; 1989, 1990, 1992, 1996, 1997, 1998, 2001 a, b, 2002); Khan and Baig, (1988, 1992); Khan and Tasnim (1989, 1990); Baig & Böhme (1991, 1996); Baig and Gvozdik (1998); Auffenberg & Rehman (1993); Woods *et al*. (1997) and Shah and Baig (2001) attempted to explore the herpeto-fauna of different areas of Pakistan and published their findings, which were surprisingly, either new to the science or extended the range of several species which were reported only from the neighboring countries of Pakistan.

Although no extensive studies on the amphibians and reptiles have ever been conducted in the Programme sites but as per preliminary Baseline report of the Indus for All Programme sites, conducted by Dr. Hafeez-ur-Rehman in 2006, 23 species of amphibians and reptiles from Keti Bunder, 31 species from Keenjhar Lake, 35 species from Chotiari Reservoir and 23 species from Pai Forest, were reported, based on collection, observation or as a result of interviews with local people or cited by the earlier authors. The site of Keti Shah, District Sukkur, was not included in those studies hence; baseline report regarding the herpeto-faunal assessment of the area is not available.

Detailed herpeto-faunal (amphibians and reptiles) assessment studies conducted during June 2007, in all the Programme sites recorded through observation and collection, 20 species of amphibians and reptiles were collected or observed from Keti Bunder, 17 species from Keenjhar Lake (District Thatta), 28 species from Chotiari reservoir (District Sanghar), 13 species from Pai forest and 11 species from Keti Shah. While in discussion with the locals and some earlier literature citations, the number of amphibian and reptilian species is expected to be much more than this. Therefore the species likely to be present in the areas have also been included in the checklist prepared. Keti Shah riverine forest was for the first time surveyed in terms of amphibian and reptile biodiversity. The studies were repeated in November 2007 to add species not represented in the earlier studies to the existing records.

The studies focused on different aspects of amphibian and reptilian biology, ecology and systematic and also addressed the issues like illegal live reptile trade, illegal poaching of freshwater turtles and lack of implementation of Government policies to meet these issues. Measures are also suggested to keep intact and conserve these vital biodiversity resources in a sustainable manner for future.

1.3.4 Birds

Data regarding water birds and wetlands of Pakistan mainly comes from Midwinter waterbed Census conducted regularly from 1987 onwards and published by IWRB/AWB in the following publications. Perennou and Mundkur, 1992, Perennou et al. 1993; Mundkur and Taylor 1993; Lopez and Mundkur 1997 and Li and Mundkur 2004.

Directory of Asian wetlands by Derek A. Scott (1989) is a remarkable achievement as it gives a series of national reports covering all countries from Pakistan in the west, China, the Koreas, Japan, The Philippines, Indonesia, and Papua New Guinea in the east.

The Pakistan section of the directory, 52 wetland sites have been described. These have been selected on the basis of criteria developed through the Ramsar Convention. Although it lacks information about the wetlands of the Nara Desert Wetland Complex, Deh Akro Wetland Complex, Rann of Kutch, sites in Balochistan such as Ormara, Jiwani, Hingol Hor, Ras Malan etc. but it is still a sole reference book on the wetlands of Pakistan.

Roberts et al (1986) have given a checklist of Birds of Karachi and Lower Sind. Tom Robert's two volumes of Birds of Pakistan comprise of the first complete account of the avifauna of the country. The first volume contains detailed descriptions of 347 non-passeriformes and the second volume deals with 313 species of passerines.

Later, Ghalib et al (1999) listed the Birds of Chotiari Wetland Complex based on their study during 1997. They gave the preferred habitats of the various species, threats to avifauna and proposals for management of the site. Ghalib and Bhaagat (2004) dealt with the wetlands of Indus Ecoregion. They gave the list of important wetlands along with the species of avifauna recorded.

Hasan et al (2005) have listed the fish and birds of Keti Bunder, Shah Bunder and other parts of the Indus delta. They have recorded 51 species of birds. Khan and Ghalib (2006) have given the bird population and threats to some selected important wetlands in Pakistan.

1.3.5 Freshwater Fisheries

Many diverse studies have been conducted on many aspects of fish and fisheries of the coastal areas of Pakistan. The major bulk of literature is on the biodiversity of various parts of the coastal areas. The significant work in this regards is that of Ahmed *et al.* (1976), Ali and Jafri (1986), Iqbal *et al.* (1999), Jafri *et al.* (1999), Jafri *et al.* (2000), Jalil and Kamaluddin (1981), Kazmi and Kazmi (1979), Leghari *et al.* (1999), Mirza (1986), Niazi (1976), Parashad and Mukerjee (1930), Qureshi (1965), Siddiqui *et al.* (1973), Sufi (1957, 1962). Some work on the commercial fishes has been conducted by Ahmed and Niazi (1988), Bianchi (1985) and Khan (1999). The limnological aspects of various water bodies have been covered by Baig and Khan (1976), Baqai *et al.* (1974 a, b), Dewani *et al.* (2002), Mahar *et al.* (2000) and Nazneen (1995). The water pollution in the coastal area has been documented by Amjad *et al*., (1998), Monawar *et al.* (1999) while aquaculture aspect is badly lacking and the only work documented is that of Yaqoob (1994).

1.3.6 Phytoplankton

Phytoplankton community structure in lakes appear to be well studied (Smith, 1990). Unfortunately in Pakistan except the work on Nazneen (1974) and Bri and Nazneen (1979), most of the research works concern with phytoplankton algae of temporary and permanent ponds. More over these studies are devoted only to the one species richness and many do not cover the entire seasonal variability. Many studies on phytoplankton of water bodies of this region appear not to be well

documented from an ecological point of view. The knowledge of temperate lakes and their phytoplankton is much greater that that of tropical and sub-tropical lakes. Tropical lakes appear to have different plankton community structure from temperate lakes and are mostly populated by submerged and emergent macrophytes.

Nitrogen was reported as the main limiting factor for production in tropical waters (Payne, 1986). But the shallow lakes of Salado River Basin are rich in both nitrates and phosphates (Quiros, 1989) and limitation by nutrient is not evidently contrary to most tropical aquatic eco-systems where nutrients are rapidly mineralized (Fisher, 1978; Junk & Furch, 1991); sediments of these lakes store high amount of organic matter, mainly derived from macrophytes. Macrophytes appeared as the main factor influencing structure and abundance of phytoplankton (Izaguirre & Vincour, 1994)/. Lakes with a greater biomass of higher plants showed lower phytoplankton densities. The influence of macrophyhtes on phytoplankton communities has been discussed by several authors and attributed to different factors, shading allelopathy and competition for nutrients (Welch and Cooke, 1987: Engel, 1998 and Mitchell, 1989)

In temperate region the blue green algae often dominates summer phytoplankton of both shallow and deep lakes (Sommer *et al*, 1986). In other Danish lakes poor light conditions and continuous circulation lead to the dominance of blue green algae (Chorus & Shlag, 1993). Nutrient limitation did not fulfill any obvious role, the annual pattern of phytoplankton dynamics appeared to have been dominated by hydrological and climatological features (Barone & Flores, 1984). More over the coupling of hydrological and algal seasonality is well seen in other man made lakes (Talling, 1986) and the hydrodynamic control of phytoplankton growth has been discussed by Harris (1986)

In tropical and sub-tropical lakes, seasonal cycle of phytoplankton seems to be strongly related to the water level fluctuations and the climatological features and it seems reasonable to agree with the results of Harris (1986) & Barone & Flores (1994), that abiotic factors such as flooding, dewatering, light, and mixing mainly affect the phytoplankton dynamics and also by inhabiting or delaying the development if biotic relationships (i.e. fry predation efficiency) which commonly takes place in aquatic environment.

The construction of dams creates large bodies of standing waters which may be the subject to chemical and biological changes symptomatic of eutrophication. Among the most dramatic consequences of eutrophication results in the formation of water blooms of blue green algae (Goldman & Horne, 1983). Blue green algae can release allelopathic substances which are toxic to humans (Lawton & Codd, 1991) and to other organisms (Feuillade, 1992). The occurrence of blue green algae's in Indian lakes and reservoirs has been well studies by Gopal *et al.,* (1998) and Houk, (1989).

Baker Lake is a shallow, eutrophic lake that also serves as a reservoir. The knowledge gained through this piece of work will provide a clear picture of the phytoplankton composition of the lake. Changes in water levels played an important role in the structure of phytoplankton communities. The distinct increase of secchi disc depth in lake is the main factor responsible for change in cynaphyta compositions. The improved light condition at bottom made it possible for Gloeotrchia and Amphanizomenon to establish lake population in the sediment. The migration of Amphanizomenon and Gloeotrichia transfers particularly phosphorus and nitrogen from sediment to the lake (Osgood 1988 and Barbieror & Welch, 1992). Istvanovics *et al.,* (1993) and Pettersson *et al.,* (1993) clearly confirm the phenomena.

Physical and chemical and biological features are strongly conditioned by surface level fluctuations, due to flooding and dewatering (Thornton *et al* 1990). This phenomena is clearly operative in Bakar Lake. During summer season reservoir water is intensively used for agriculture purpose. The deep outlets may also interfere with stratification patter (*Calvo et al., 1984*). In addition the reservoirs often become so shallow that they can no longer accommodate a stable thermocline (Calvo *et al,*. 1993), such instable conditions tend to affect the dynamics of planktonic communities (Barone et al., 1991, Flores and Barone, 1994). Due to out flow of water and in absence of in-flow a marked interfere with stratification pattern and effect on the dynamics operative of composition of the planktonic operative in composition of planktonic

1.3.7 Zooplankton

A review of literature shows that some works on morphology, anatomy, larval development, breeding and fecundity, zoogeography, parasitism, associations, ecology, bionomics, distribution, food, fisheries, biochemistry, nutritive value, bioassay, biotechnology and some other issues relating to invertebrates has have also been carried out in Pakistan though in inadequate quantity. Some important works Include Ali (1983), Baqai and Ishrat (1973), Baqi (1975), Jafri (1995), Jafri and Mahar (2003a, 2003b), Jafri (1999), Leghari (1999) on the zooplankton.

Some work on crustaceans include Ahmed (1985), Ahmed and Khan (1971), Ahmed and Moazzam (1982), Ahmed (1973), Kazmi and Siddiqui (1992, 2001, 2006), Kazmi and Tirmizi (1990, 1995b, 1999), Kazmi and Yousuf (2005), Kazmi (1973, 1975, 1990, 1991, 2000, 2001), Keenan (1998), Kemp (1917), Khan (1975a, 1976b, 1977b), Khan and Ahmad (1975), Kholi (1992, 2004), Moazzam and Rizvi (1985), Moazzam (2003), Mustaquim (1972), Mustaquim and Rabbani (1976), Niazi and Hoque (1974), Nayeem (1993), Qadri (1960), Siddiqui and Kazmi (2003), Siddiqui and McLaughlin (2003), Siddiqui (2004), †Stoliczka (1871), Tirmizi (1962, 1967, 1968, 1970a, 1970b, 1974, 1976, 1977, 1978, 1980), Tirmizi and Ahsanullah (1966), Tirmizi and Bashir (1973), Tirmizi and Ghani (1978, 1982a, 1982b, 1983, 1986, 1988a, 1988b, 1992a,

In Pakistan there is still a dearth of specific literature and information regarding most of the zooplankton groups and for most of them the taxonomic investigations have not been scratched though there are examples of fragmented efforts including Haq and Rehman (1973), Haq (1973), Ali (1983), Biswas (1971), Iqbal and Baqai (1976), Jafri (1999), Leghari (1999). The quantum of work done and being done on zooplankton seems diminutive as compared to the huge scope and diversity of the invertebrate fauna in Pakistan. Most of the zooplankton fauna of Pakistan is therefore still uncharted and requires insightful and devoted scientific attention. Qadri and Baqai (1956) and Jafri and Mahar (2002) made some endeavors in order to explore the Branchiopod fauna of Pakistan including the riverine and terrestrial species.

1.3.8 Physico-chemical properties of water

In Pakistan, there are several potential sources to contaminated water. Bacteriological contamination of drinking water has been reported to be one of the most serious problems throughout the country in rural as well as urban areas (Abid & Jamil, 2005; Kahlown, Tahir, & Sheikh, 2004; Jehangir, 2002; Sun-OK, Shin-Ho, Nasir, & Noor-us-Saba, 2001). Another strong source for ground water and ponds / wetlands contamination is chemical pollution from toxic substances from the industrial effluents, pesticides, nitrogenous fertilizers, arsenic and other chemicals (Din, Hussain, Naila, Shabbir, Rana, Anwar, Saeed, & Zumra, 1997;

Tahir, Chandio, Abdullah, & Rashid,1998; Sajjad & Rahim,1998; Hussain & Mateen, 1998; Sial & Mehmood,1999; Latif, Akram, & Altaf,1999; Chandio,1999; and Tahir, 2000). In addition, excessive monsoon rains, floods, herbicides, fungicides, untreated municipal waste, sewage breakdowns, and coastal water pollution due to waste discharges and oil spills are extremely hazardous which pollute water. An abundant supply of good, clean water must support a variety of beneficial uses. These include drinking water for domestic use and stock watering; industrial, commercial, agricultural, irrigation, and mining use; fish and wildlife maintenance and enhancement; recreation; generation of electrical power; and preservation of environmental and aesthetic values. Water quality factors are important in freshwater aquaculture systems. Water quality determines not only how well fish will grow in an aquaculture operation, but whether or not they survive. Fish influence water quality through processes like nitrogen metabolism and respiration. Some water quality factors are more likely to be involved with fish losses as dissolved oxygen, temperature, and ammonia. Others, such as pH, alkalinity, hardness and clarity affect fish, but usually are not directly toxic.

Fish are important not only for ecosystem function, but also may provide socioeconomic value in the form of fishery resources for people. Loss of fish species due to changes in water quality or over-fishing may result in dramatic shifts in ecosystem dynamics, as grazing pressure on invertebrates and algae can be released, enabling rapid growth and potential blooms of algal populations.

The majority of the subtropical and tropical coastline is dominated by mangroves, estimated to cover an area of 22 million hectares. However, over the past several decades, the global area in mangroves has increasingly diminished as a result of a variety of human activities, such as over harvesting, freshwater diversion and conversion to other uses" (Snedaker, S. C.,1993).

Pakistan is largely arid and semi-arid, receiving less than 250 mm annual rainfall, with the driest regions receiving less than 125 mm of rain annually. It has a diverse landscape, with high mountain systems, fragile watershed areas, alluvial plains, coastal mangroves, and dune deserts. The flora and fauna are mainly Palaerctic and Indo-Malayan. Forests cover approximately 4.58 million ha (5.7 percent) in Pakistan. (Government of Pakistan, 1996) Of these, 0.132 million ha (less than 3 percent) are coastal mangrove forests. Pakistan is divided into 18 habitat types, among them mangrove forests, which occur mainly in the Indus Delta and in a few patches westward along the Baluchistan Coast.

There has been considerable qualitative and quantitative loss of mangrove forest in Pakistan over the last 50 years. A significant reduction in the river water supply and increased marine water pollution in the Indus Delta as well as over harvesting of mangroves by the local communities, sedimentation, and coastal erosion are generally considered to be the proximate causes of this loss. Another threat is emerging in the form of over harvesting of fish resources, largely provoked by increased pressure for exports with little or no consideration for the existing environmental laws and regulations. Policies and decisions made at the national and international levels have determined these proximate causes.

Chapter 2:
Material and methods

2.1 Large Mammals

2.1.1 Team composition

Apart from the permanent team members from WWF Pakistan, different professionals, field biologists and supporting staff members from different site offices of Indus for All Programme, Sindh Wildlife Department, Sindh Forest Department and Karachi University accompanied the study team. The study teams comprised of 6-9 members for different sites during summer and winter surveys. Details of study teams for each site are given in the annex document.

Most of the large mammals reported from the sites are mostly nocturnal whereas few diurnal medium sized and larger mammals are also distributed in the area. The aquatic mammals are reported only from Keti Bunder and Keti Shah. Therefore, different direct and indirect methods of detection were applied; first to locate various mammalian species and secondly, to estimate the populations of some mammals of concern. The following direct and indirect observation methods applied during the survey included.

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 and then calculated an index of abundance of each species as the number of animals seen per hour of observation (Brower *et. al* 1990). The point survey methodology for population estimation was applied in Pai forest for Hog deer and in Chotiari Reservoir to have some estimates of feral donkey of Achhro Thar.

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 to locate and to have population estimates of different mammalian species.

Roadside counts technique was applied in Keti Bunder, Chotiari Reservoir and Pai Forest mostly for the nocturnal mammals like foxes, jackals, cats, hog deer and wild boar as well as for the diurnal mammals like mongooses. For this purpose, 4x4 vehicles were used which were driven at a slow speed (7 km/hr) on inter-compartmental tracks in Pai forest, sandy plains and canal banks in Chotiari reservoir area (4 km/h) and on rough tracks along water channels in Keti Bunder (3 km/h). These roadside counts were carried out during early morning at dawn and during night by using search lights.

In Chotiari reservoir, about 4 km area along the bank of Nara canal was searched for hog deer and Indian otter, 8 km area along the northern embankment of Chotiari reservoir, 5 km area along southern embankment of Chotiari reservoir up to Bakaar and about 16 km in Achhro Thar desert dunes to find the mammals like foxes and feral donkey.

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 counts technique was applied at all the five study sites and this method proved to be the most effective one. By using this method at Chotiari reservoir we were able to determine the presence of species such as Indian otter (*Lutrogale perspicillata*), Hog deer (*Axis porcinus*) and Fishing cat (*Prionailurus viverrinus*) along Nara canal, Indian desert fox in Keenjhar and jackals in Keti Bunder.

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 distances at which they were seen or flushed. The average of the flushing distance is determined and used to calculate the effective width of the strip covered by the observer. The population for the entire area then is considered to be the number of animals flushed, divided by the area of the strip and multiplied by the total area (Schemnitz 1980).

P = AZ / 2XY	**P** = population **A** = total area of study **Z** = number of animals flushed **Y** = average flushing distance **X** = length of strip

Line transects or strip census method is a particularly useful technique when animals are difficult to see and must be flushed to be counted. This methodology was applied in Chotiari Reservoir for some species.

2.1.6 Pellet counts

Pellets' counting in a specific area is a good technique for locating large mammals and assessing their populations. This technique involves removing all pellet groups from plots and then estimating from subsequent observations on those plots the 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 (Brower *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 the 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 pellets, 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 five 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 Live trapping of nocturnal mammals

It was difficult to confirm the existence of some carnivores through above methods because most of the carnivores found in study sites are nocturnal and difficult to locate and observe during day time. Since it is difficult to differentiate between some mammals belonging to Felidae family on the basis of their pug marks techniques for trapping some carnivores were applied and traps were made for trapping live animals such as jungle cat, grey mongoose etc. Such specially designed traps were set for the animals and the trapped animals were released after having been photographed. The traps were designed in such a way that there were no chances of any damage to the animals.

2.1.9 Equipments and Field Kit

Equipments and field kits used for watching different mammals and assessing their populations in different sites of the Indus for All Programme 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 (10x 50) 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

One effective way to survey small mammals is 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, Hystrix,* and *Hemiechinus*. This method is most effective for those small mammals which can not 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 torch light, sticks, long boots, gloves etc

The following sites were identified and used for sampling:

Table 2 – Locations used for sampling in Chotiari reservoir

S.no	Northing	Easting	Location name
1	26 12 065	69 13 119	Noon Gharo Lake, zero point
2	26 06 824	69 09 436	Bakar/outlet
3	26 06 824	69 09 438	Bakar/outlet
4	26 06 824	69 09 438	Bakar/outlet
5	26 06 824	69 09 438	Zero point/baker
6	26 06 824	69 09 438	Baker/Zero point
7	26 09 990	69 12 937	Zero point/baker
8	26 11 638	69 03 628	Akan-wari pump station
9	26 06 422	69 01 416	Paksiri
10	26 06 422	69 01 416	Paksari/Hongorjo village
11	26 06, 422	69 01 416	Paksiri
12	26 06 824	69 09 438	Bakar/ outlet
13	26 12 219	69 12 674	Zero point
14	26 06 824	69 09 436	Baker
15	26 06 824	69 09 436	Baker
16	26 11 638	69 03 628	M Usman Ibopoto

2.2.1 Bait

A mixture 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 for fragrance. This bait was found highly successful in the study area probably due to the overall food shortage and fragrance. Freshly prepared bait was used on every trapping day. Only small amounts of bait were put on the rear side of the traps. Care was taken to make sure that the 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 set at a specific area on a line approximately 500 m long and traps were set approximately 10m 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 of each species was 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 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 herpeto-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 coloured. This renders survey on 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 limitation.

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 daytime. 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 pools, 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 in 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, studies were conducted, prior to the start of the hibernation period of most of the amphibians and reptiles. Most of the active searching was only possible and limited to the pre-dusk time in winter, 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 the ground, along the path or the pond/stream bank. Night survey in some of the rocky terrain around the Keenjhar Lake was difficult as there was always a likelihood of venomous snakes, as the author did face; so, long shoes, hand lamps and powerful torches were used for this purpose.

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. It is also not recommended in the rocky terrain and steep slopes. The most suitable location for such traps is the sandy habitat, which yields great success in trapping the animals. In the present studies the pitfalls were placed at only one location in Chotiari reservoir site, RD-174 (26° 07′ 234″, N 69° 08′ 657″ E), for about three days (and nights as well) during the summer studies. The drift fences, 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, faecal 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.

Image 1 – tracks of snake species

Image 2 – Saw-scaled viper caught at Chotiari Reservoir area

2.3.5 Collection

Hand picking (through bare hands or with the help of long forceps or snake clutch), adop

ted for the present studies, has always been the most efficient way of collecting different species of amphibians 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 therefore a large number of toads were spotted with this method.

2.3.6 Data Records

The species collected or observed during the survey were photographed with a 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 transported to the Pakistan Museum of Natural History (PMNH) laboratory for future reference.

2.3.7 Preservation

The amphibian or reptile specimens were arranged in a tray or ice-cream container 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 injected to preserve the internal organs. This step was omitted in case of frogs as they have thin and permeable skins, but in case of reptiles, the preservative was injected into their bodies as their skin is impermeable and does not allow any solution to get into. For this purpose normal syringes were used. The specimen was stored in the same preservative in a watertight jar. A waterproof 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, 2006).

2.3.9 Data Analysis

There are several numerical indices in use, which quantitatively 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

2.4.1 Survey Method

Each major habitat type in the study area was identified and records were kept of species of birds found in each discreet habitat such as lakes, canals, ponds, marshes, coastal areas, creeks, forest, agriculture fields, mangrove areas, vicinity of human habitation and fallow lands. The number of birds observed in each habitat type was also recorded with particular emphasis on the key species and to relate the data to other components of the study area such as vegetation, water and soil etc. 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, and marine systems 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 2 observers, separately. Birds were searched on each side of the strip for 150m so that each study strip was 300m wide. Use of binoculars and telescopes was made to identify bird species, count or assess bird numbers, particularly in case of water-birds.

2.4.2 Evaluation of water bird numbers

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

a) Counting individuals 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 the "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, 2,3,4,5,6,7…… etc.
- Distant viewing of an evenly distributed flock. Counting 1,2,3,4,5,6,7……..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).

2.5 Freshwater Fisheries

2.5.1 Fish surveys:

There are five techniques for fish surveys viz., Bank side counts, trapping, cast netting, gill netting and electro-fishing (Environment Impact Assessment Ordinance Guidance note no. 10/2004, Singhanouvong and Phouthavong, 2002). Bank side counts are only done on the banks of clear shallow streams, Trapping is done by using specific baits for specific species, Gill netting is only for commercial fishes while electro-fishing is done only in wade able streams with limited width. The cast netting technique is, therefore, the most appropriate technique for large rivers and reservoirs while studying the fish biodiversity.

2.5.2 Cast netting technique:

A general survey of the reservoir area was conducted to identify different habitats in the study area. Field stations were selected covering all the representative habitats of the study area. Long/Lat of all the field stations was noted to make it more accessible during the study period. Fish will be collected using cast nets of two different mesh sizes, (small one having mesh size of 1cm X 1cm and having a circumference of 30 ft. and the large one with mesh size of 2.5cm X 2.5cm and with a circumference of 45ft.) so that the fish fauna of all the age classes could be collected. Ten nets of each mesh size were cast in each stations along a line transect of about 500 meters. The collected material was numbered according to stations and the effort no. and mesh size. The fish specimens were preserved in 10% formaldehyde solution in the field. Large specimens were given an incision in the belly to ensure proper preservation. The specimens were identified in the laboratory and taxonomical checklists along with English and local names were compiled.

The status of each species (common, rare, fishery value, maximum size etc.) was determined on the basis of relative abundance of each species in the project area. The data on fish species collected in each station and of every habitat along with their long/lat. was available for developing GIS based information regarding occurrence and distribution of fish species in the lake. Any possible change in the last ten or so years in fish population fish was anticipated on the bases of data collected, previous studies carried out in the area and on the basis of interviews of the fishermen and local people, agro-forestry practices and irrigational pattern in the area and conservational measures that could be expected in future. The fishes of special concern i.e., fishes of economic value and fishes of ecological concern were given special attention and were documented and enlisted on the basis of the first hand information collected by the actual data and the information already available through previous studies.

2.6 Phytoplankton

Algal and phytoplankton species were collected in June and November 2007. A small boat was used along with a phytoplankton net of 5-10 µm mesh to collect samples. Water samples were collected each time using a water sampler (Nansen bottle) commonly unused for studying physico-chemical features, using standard methods (APHA, 1985) and for identification of phytoplankton. Samples were preserved in 4% formalin solution (Mason, 1967). The species composition was determined by utremohal method (Lund, 1958). The micro algae (ultra nano-plankton) were not counted as Gorham et al (1974) considered these algae comparatively un-important in high productive water-bodies. Identification and counts were done using inverted light microscope (BH-2 Olympus using objectives 10^X, 20^X, 40^X, 100^X but usually 20^X and 10^X eye piece was used) and identified with the help of available literature (Tilden, 1910; Husted, 1930; Majeed, 1935; Smith, 1950; Silva, 1954; Desikachary, 1959; Prescott, 1962; Siddiqi & Farooqi, 1964; Patrick, 1966; Philpose, 1967; Islam & Tahmida, 1970; Tiffany & Briton, 1970; Vinyard, 1979; Akiyama & Yamagishi, 1981; Shameel, 2001).

2.7 Zooplankton

2.7.1 Collection protocols and standardizing procedures

Specimens belonging to diverse groups of Invertebrates were collected from the various localities of the prescribed areas using a variety of collection protocols and techniques.

2.7.2 Aquatic invertebrate fauna - plankton net and drag nets:

The most widely used apparatus for collecting zooplankton is the plankton net. This, despite many minor variations in pattern, consists essentially of a cone of bolting silk, (or equivalent material) mounted on a ring or hoop to which are attached three thin bridles spliced on to a smaller ring by means of which the net can be shackled to a towing rope or warp. The end of the cone is left open and is reinforced by strong material, tapes or cords are sewn to this so that a small metal or glass jar can be tied into it. The jar receives most of the plankton as the net is towed along, but some always remains on the wall of the net and is removed by turning the net inside–out and washing it in a wide- mouthed receiving jar, holding about a liter of water. The sample was then preserved in the preservative chemicals.

The plankton net was towed slowly behind the boat and mostly a five-minute or even less haul was usually sufficient to give an adequate amount of zooplankton. The mesh size of the material of which the net is constructed influences the kind of plankton caught. As the focus of the present study has been the macro-zooplankton, therefore, plankton net of mesh size 0.03 mm was selected. (G. E.Newell and R. C Newell, 1963)

2.7.3 Random sampling

The distribution and abundance of invertebrates are strongly influenced by abiotic factors, such as light, depth, temperature, salinity, tides and time of year (i.e. seasonal effects). Zooplankton, for example, is unevenly distributed over wide space and time scales in the water bodies. As it was not possible to sample all of the zooplankton from the lakes and other reservoirs using a single collection method, random sampling was therefore used as the probable procedure in which each and every species has the equal chance and probability to be caught during sampling. Each individual is chosen entirely by chance and the likelihood of a biased data collection is thus reduced.

2.7.4 Precautions in field

i. Sample labels are properly completed, including sample ID, date, stream name, ample location, and collector's name, and placed into the sample container. The outside of the container should be labeled with the same information.
ii. After sampling at a given site, all nets, pans and trays are rinsed thoroughly, examined and picked free of organisms or debris. Any additional organisms found should be placed into the sample containers.

2.7.5 Precautions in taxonomic investigation

i. A voucher collection of samples is maintained. These specimens are properly labeled, preserved, and stored in the invertebrate repository for future reference.
ii. The reference collection of each identified taxon is maintained and specimens sent out for taxonomic validations are also recorded with the label information and the date sent out. Upon return of the specimens, the date received and the finding are also recorded with the name of the person who performed the validation.
iii. Information on samples completed (through the identification process) is recorded in the log register to track the progress of each sample. A library of basic taxonomic literature is maintained and frequently revitalized to ensure accurate identifications.

2.7.6 Hand picking and use of forceps

Hand picking, through bare hands or with the help of long forceps, which has been adopted for the present studies, is by far the most productive method for collecting different groups of terrestrial invertebrates especially arachnids (spiders, solifugids) and myriopods etc. The specimens collected or observed during the survey were photographed with digital camera and significant field data were recorded. The voucher specimens collected were transported to the PMNH laboratory for future reference.

2.7.7 Preservation and storage of the specimens

All invertebrate specimens including the zooplankton were preserved by the addition of grades of formaldehyde and 70 % ethyl alcohol. These fluids suffice to preserve the samples indefinitely and also have the effect of sending all the plankton to the bottom of the jar. All zooplankton are delicate and easily get damaged, so sample handling was gentle. It is advisable not to concentrate the sample too much. Zooplanktons were sub-sampled by adding water to bring the samples to a known volume (500 or 1000 ml). The concentrated samples were then stored in suitable bottles and plastic screw tapped jars. The date, place of origin, mesh-size of the net, length and depth of the haul were written in Indian ink on quality paper and placed in the jar as the labels outside usually peel off after some time.

2.8.7 Counting and studying the zooplankton

The volume of the zooplankton is determined by the displacement method. First the total volume of the concentrated sample plus the preserving fluid is measured. Then the plankton is filtered off, using a filter paper in a funnel, and the volume of the filtrate is measured. The volume of the plankton is then obtained by the difference between the two volumes. A measure of the total catch is also made by weighing the filtered plankton. One ml of the concentrated sample may contain so

many organisms that it would be very difficult to count them. One ml of the concentrated sample was therefore diluted to 100 ml and out of this diluted sample, one ml was taken. Identification and counting the samples was done under a dissecting microscope with dark-field illumination. Staining was not required although a drop of glycerin was put on each individual specimen isolated from the jar in order to avoid any damage to the samples.

2.9 Physico-chemical properties of water

2.9.1 Summary

The samples were collected in pre monsoon (July 2007) and post monsoon (October 2007) period. The samples were collected in clean acid rinsed bottles for the general water quality parameters such as pH, temperature, conductivity TDS, Total Hardness, Chlorides, Phenol, Sulphates, turbidity, ions and four heavy elements. The BOD and 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 water quality 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 deployed at the study area. The sampling scenario was designed to cover some town area and creeks that should highlight the environmental effects on livelihoods. The location points and their significance are highlighted in **Table 3**. Water samples were drawn considering full depth of standing water or flowing water. The sample location points were marked on GPS maps GPS which will be used as reference points for future studies.

Table 3 – Significance of sample location points

S. no	Sample no.	Sample Location	Geo-reference	Significance
1	CR-B1	In side reservoir RD-157	N2606026 E6908678	South side (To get overall picture of the water quality in the reservoir south and north sides samples were taken)
2	CR-B3	Bakar Lake: Near Haji Islam Larik village	N2605795 E6909679	This lake has been disconnected from the fresh water coming from the Ranto canal of Indus river off taking from Nara Canal. The lake is getting seepage water.
3	CR- B4	Dogrion Lake	N2604621 E6908106	This lake has developed after the reservoir construction and water quality is changing from last few years as reported by community due to seepage water coming from main reservoir
4	CR-B5	Village Mungria-Hand pump	N2604234 E6908497	Water quality has deteriorated due to seepage coming from the reservoir as reported by the community.
5	CR-B6	Chotiari City: Hand pump	N2603397 E6911608	Water quality is brackish after 2002 (inception year of the reservoir) as reported by the local affected community and verified physically.
6	CR-B7	In side Chotiari at RD-55,	N2611468 E6900915	Western side: This location represents the other side of the reservoir where seepage water is being collected through

				open drain for pumping back in to the reservoir.
7	CR-B8	Outside Chotiari reservoir at RD-55	N2611468 E6900915	This sampling point represents the seepage water coming from the reservoir which is ultimately being pumped back in to the reservoir at pumping station.
8	CR- B9	Pumping station	n/a	The seepage from the reservoir and from the adjacent agriculture area is drained through surface drains and then pumped back into the reservoir
9	CR-B10	Village Sono Rajar	n/a	Influence of reservoir on groundwater (GW)
10	CR-B11	Padhrio lake	n/a	Highly saline lake inside reservoir- The consideration to this point was given because the rise of water level in the reservoir may join this lake and may degrade the overall quality of the reservoir.
11	CR-B12	Sabbojho village	n/a	Well water

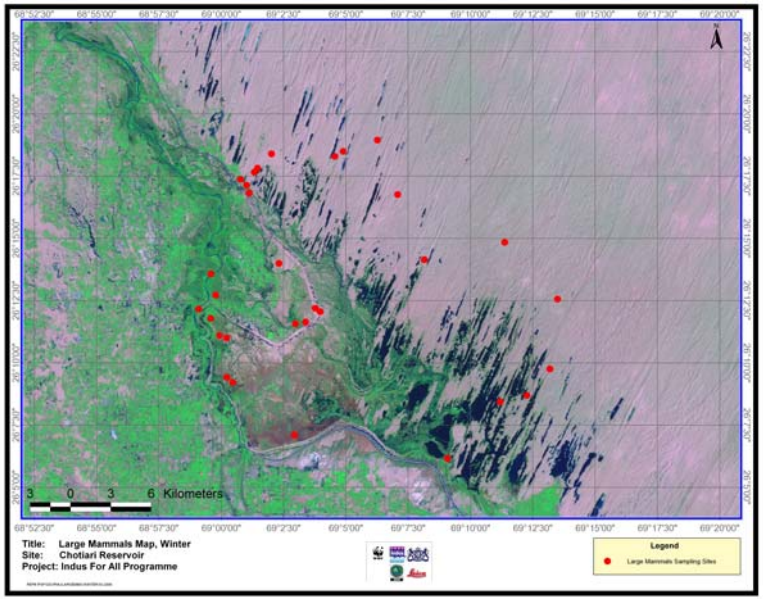
Chapter 3:
Findings and discussion

3.1 Large Mammals

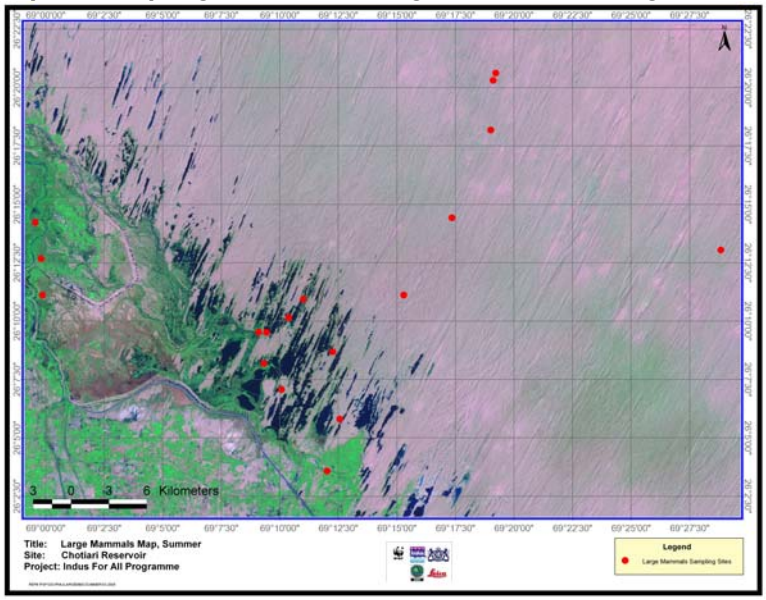
3.1.1 Sampling Sites

Almost all the potential sites around Chotiari wetlands complex were searched to locate the existing large mammals and the GPS coordinates at different locations were noted. Different sampling sites and the distribution of large mammals around Chotiari reservoir during summer and winter surveys are given in **Map 2** and **3** respectively whereas GPS coordinates taken during summer and winter surveys are given in annex document.

Map 2 – Sampling locations of large mammals during winter



Map 3 - Sampling locations of large mammals during summer



3.1.2 Species identified

Spending eight days in the field (four days during summer survey in June 2007 and another four days during winter survey in January 2008) a total of 58 animals of 14 different species, belonging to three orders (Carnivora, Artiodactyla and Perissodactyla) were recorded from the study area as given in the **Table 4** below.

Table 4 – Mammals recorded from Chotiari Reservoir

S.no	Common Name	Zoological Name	Order	Animals Observed
1	Asiatic jackal	*Canis aureus*	Carnivora	3
2	Caracal or Desert lynx	*Felis caracal*	Carnivora	-
3	Jungle cat	*Felis chaus*	Carnivora	1
4	Fishing cat	*Prionailurus viverrinus*	Carnivora	-
5	Indian desert cat	*Felis sylvestris ornata*	Carnivora	-
6	Bengal fox	*Vulpes bengalensis*	Carnivora	2
7	Desert fox	*Vulpes vulpes pusilla*	Carnivora	2
8	Indian otter	*Lutrogale perspicillata*	Carnivora	-
9	Small Indian mongoose	*Herpestes javanicus*	Carnivora	13
10	Grey mongoose	*Herpestes edwardsi*	Carnivora	3
11	Hog deer	*Axis porcinus*	Artiodactyla	-
12	Indian wild boar	*Sus scrofa*	Artiodactyla	-
13	Chinkara	*Gazella bennettii*	Artiodactyla	3
14	Feral donkey of Thar	*Equus spp.*	Perissodactyla	34

3.1.3 Observation Records

Out of 14 recorded species of large mammals, eight were observed directly while six mammals were recorded on the basis of indirect evidences like tracks, faeces and interviews of locals and wildlife watchers from Sindh Wildlife Department. Observation records of different mammalian species at Chotiari Reservoir are given in the **Table 5** below.

Table 5 - Observation records of different mammal species at Chotiari reservoir

S.no	Species	Direct Observation	Indirect Observations		
			foot prints	fecal material	Interviews with locals
1	Asiatic jackal	✓	-	-	✓
2	Caracal or Desert lynx	-	-	-	✓
3	Jungle cat	✓	-	-	✓
4	Fishing cat	-	✓	-	✓
5	Indian desert cat	-	-	-	✓
6	Bengal fox	✓	-	✓	✓
7	Desert fox	✓	-	-	✓
8	Indian otter	-	✓	-	✓
9	Small Indian mongoose	✓	-	-	✓
10	Grey mongoose	✓	-	-	✓
11	Hog deer	-	✓	-	✓
12	Indian wild boar	-	✓	-	✓
13	Chinkara	✓	-	-	✓
14	Feral donkey	✓	-	-	✓

3.1.4 Conservation Status of Recorded Mammals

Out of the 14 recorded species, one is Critically Endangered (CE); two are Vulnerable (VU), five Near-threatened (NT), four Least-concern (LC) and one Data Deficient (DD) according to the IUCN Red List of Pakistan Mammals 2005 while the status of feral donkey is not known. Jungle cat and small Indian

mongoose are enlisted as Least Concern (LC) while fishing cat as Vulnerable (VU) in IUCN international Red List 2006. Caracal, Jungle cat, Fishing cat, Indian desert cat, Indian otter, Hog deer and Chinkara are protected (P) in Sindh. Jungle cat, Fishing cat and Indian desert cat are listed in Appendix II while Caracal and Hog deer in Appendix I of the CITES Category 2007 (**Table 6**).

Table 6 - Conservation status of mammals found at Chotiari reservoir

S.no	Mammalian Species Recorded from Chotiari reservoir	IUCN International Red List 2006	IUCN Pakistan Red List 2005	Sindh Wildlife Protection Ordinance 1972	CITES Category 2007
1	Asiatic jackal	-	NT	-	-
2	Caracal or Desert lynx	-	CE	P	Appendix I
3	Jungle cat	LC	LC	P	Appendix II
4	Fishing cat	VU	NT	P	Appendix II
5	Indian desert cat	-	DD	P	Appendix II
6	Bengal fox	-	NT	-	-
7	Desert fox / Red fox	-	NT	-	-
8	Indian otter	-	NT	P	-
9	Small Indian mongoose	LC	LC	-	-
10	Grey mongoose	-	LC	-	-
11	Hog deer	-	VU	P	Appendix I
12	Indian wild boar	-	LC	-	-
13	Chinkara	-	VU	P	-
14	Feral donkey	-	-	-	-

Legend: CE = Critically Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, DD = Data Deficient, P = Protected

3.1.5 Population Estimations

Populations of four mammals were estimated at Chotiari Reservoir that is given in **Table 7** below.

Table 7 – Estimated populations of mammal species at Chotiari reservoir

Sr. No.	Common Name	Zoological Name	Estimated Populations
1	Feral donkey	*Equus sp.*	90
2	Indian otter	*Lutrogale perspicillata*	12
3	Chinkara	*Gazella bennettii*	5
4	Hog deer	*Axis porcinus*	7

3.1.5.1 Population of Indian otter

During the four days survey of Chotiari reservoir during summer, the existence of Indian otter (*Lutrogale perspicillata*) was confirmed along Nara canal at the following two places.

Near RD 65 at: N 26º 12’ .402” and E 68º 59’ .482” and near the village Shero Mangwanoo between RD 78 & 79 at: N 26º 10’ .665”, and E 68º 59’ .520”.

Image 3 – Otter print from Chotiari Reservoir

Image 4 - Otter habitat in near Nara canal, Sanghar District

For searching the Indian otter in Chotiari Reservoir, three transects were taken each of two km length along the south western bank of the Chotiari Reservoir. These transects were taken on 4x4 jeep being driven at a constant speed of 5 km per hour and about 30 meter area on both the sides was searched. Fresh foot prints, about one to two days old, were observed in two transects out of the three. At RD 65, towards the Chotiari Reservoir, fresh foot prints of 4 animals were observed while between RD 78 and 79, towards the Nara canal, the foot prints of 3 animals were observed. Photographs of these foot prints were taken as an evidence of the existence of the Indian otter in the Chotiari Reservoir which was considered as extinct in Chotiari Reservoir prior to this survey. Based on tracks counting method, a minimum population of otter in Chotiari Reservoir was estimated as 7 animals. Observation records of Indian otter at Chotiari Reservoir during summer survey are given in the **Table 8** below.

Table 8 – Observation records of Indian otter at Chotiari during summer survey

Sr. No.	GPS Coordinates	Location	Estimated Animals
1	N 26º 10' 665" E 68º 59' 520"	Along Nara canal, Near Village Shero Mangwanoo, between RD 78 and 79	3
2	N 26º 12' 402" E 68º 59' 482"	Near RD 65 along embankment of Chotiari reservoir	4
Total observed animals			**7**

During winter survey in January 2008, the locations along Nara canal where the tracks of otter were observed during summer survey were visited again but no evidence of otter were found this time as the canal was dry during winter season. However, otter was located at three other locations during winter survey. About 12 animals were estimated at Chotiari Reservoir during winter survey based on foot prints as given in the **Table 9** below.

Table 9 – Observation records of Indian otter at Chotiari reservoir during winter survey

S.No.	GPS Coordinates	Location	Estimated Animals
1	N 26º 17' 221" E 69º 00' 466"	Chor Dhand, near inlet of Chotiari Reservoir	8
2	N 26º 09' 244" E 68º 59' 739"	Ditchoon Dhand, near village Sarmast	2
3	N 26º 13' 594" E 69º 02' 193"	Near village Usman Ibo Poto	2
Total observed animals			**12**

3.1.5.2 Population of feral donkey

Feral donkeys of Achhro Thar (*Equus sp.*) are reported to exist in large numbers (circa 500 – 600) by locals along North -Eastern side of the Chotiari reservoir. In very limited time of 3 days during the present survey, some estimates were made about its population in the study area.

Image 5 – Watering point for feral donkeys in Sanghar District

Image 6 – Vantage point to observe feral donkeys in Sanghar District

A small hose near a well for watering the livestock in Achhro Thar area called Tarr is used for trapping these wild donkeys. Feral donkeys use to come for drinking water at these water points at night but the hunters set traps here and capture these animals in large numbers. Eight different such Tarr (watering points) were identified in the area where trapping is practiced and these include;

1. Mokro Tarr
2. Baandio Tarr
3. Mumvo Tarr
4. Mokhat Tarr
5. Ghoray Aaro Tarr
6. Guddu Hungoor Jo Tarr
7. Soniaro Tarr
8. Wasayo Tarr

Three different trapping sites of asses were visited and marked as vantage points and point surveys were conducted to have some estimates of their population. The vantage points are given in **Table 10** below.

Table 10 – Vantage points in Achhro Thar area of Chotiari reservoir for feral donkeys

Sr. No.	Vantage Point	Location	Animals Observed	Average %
1	Baandio Tarr	N 26º 19' .971" and E 69º 19' .134"	9	11.33
2	Mokhat Tarr	N 26º 19' .783" and E 69º 19' .068"	14	
3	Soniaro Tarr	N 26º 17' .705" and E 69º 19' .006"	11	

At the first vantage point i.e. Baandio Tarr; nine donkeys were observed using binoculars and spotting scope during half an hour from 8.30 am to 9.00 am. At the second vantage point, Mokhat Tarr, 14 animals were observed from a sand dune with the help of binoculars and spotting scope during 45 minutes from 9.30 am to 10.15 am. At the third vantage point, Soniaro Tarr, 11 animals were observed in about half an hour from 11.00 am to 11.30 am.

The average of animals at the above three vantage points was 11.33 and there are eight such vantage points. Achhro Thar is a vast desert along north – eastern side of the Chotiari reservoir and provides an excellent habitat for this wild animal along with good shelter in sand dunes and favorite browse like S*alvadora persica* and *Salvadora oleoides*. As the exact area of this particular habitat of asses of Achhro Thar is not known therefore, the average population of this animal around all the eight vantage points can be estimated as;

Average population around one vantage point	= 11.33
Population around 8 vantage points	= 11.33 x 8
	= **90 animals**

Thus according to a rough estimate the minimum population of the asses of Achhro Thar in and around Chotiari reservoir area is approximately 90.

3.1.5.3 Population of Chinkara (Indian gazelle)

Chinkara is not found in the wild in Chotiari reservoir rather it exists in a privately maintained wildlife park in Chotiari reservoir known as Sona Jonejo. Sona Jonejo is a small island in Chotiari reservoir about 1.5 km long and at maximum about 400 meters wide and is located between N 26º 09' .689", E 69º 10' .230" at eastern side, N 26º 10' .560", E 69º 10' .603" at northern side, N 26º 08' .910", E 69º 08' .865" at western side and N 26º 08' .107", E 69º 08' .795" at southern side. There are 3 households comprising of 10 members living on this island and supported by the owner of the wildlife park with 100 goats, 40 cows and 10 buffaloes. Four pairs of Chinkara were introduced here by Mr. Kareem Daad Junejo during 1974 - 75 when he established this wildlife park. Those four pairs flourished in late 1970's and 1980's but due to very small and isolated home range, existence of caracal in the area and due to some diseases, its population has decreased and now only 5 animals are surviving.

3.1.5.4 Population of Hog deer

Hog deer was found in Chotiari reservoir only along Nara canal and by applying track count methodology a population of 7 animals was estimated. These estimates of hog deer population are in addition to the populations existing in Makhdum Amin Faheem's and Pir Pagara's Mohari or Rakh (game reserve) which are located along the northern bank of Nara canal. Makhdum Amin Faheem's Mohari starts at N 26º 12' .747", E 69º 59' .579" and ends at N 26º 13' .734", E 68º 59' .337" covering about 1.5 km along Nara canal in East – West direction and about 700 meters along North – South direction. Peer Pagara's Mohari starts from the end point of Makhdum Amin Faheem's Mohari and covers an area of about 5 km along Nara canal in East – West direction and about 8 – 10 km in North – South direction. Both the Moharies are densely vegetated mainly with *Typha angustata* and it is very difficult to cross or move through these Moharies. Secondly, no one can trespass these Moharies without permission. Thus, these private game reserves provide a good habitat and shelter for Hog deer. The owners themselves or their guests are only allowed for Hog deer hunting and according to the locals, more than 100 Hog deer exist in these private game reserves.

Hog deer hunting in these game reserves is practiced in a specific manner and the *Typha angustata* is cut in such a way that a straight passage is made about 300 meters long and 5 meters wide. This passage is called Paha and the hunter sits at one end waiting for Hog deer to cross the road being flushed by the

helpers. The hunter has a very short time to aim and shoot as the Hog deer cross the road quickly.

The population of Hog deer in these private game reserves can also be estimated by using these Pahas but it is possible only if the owners allow doing so.

3.1.6 Threats and recommendations

3.1.6.1 Threats

- **Hunting:** after the construction of embankments along Chotiari reservoir, access to different areas has become easier and hunters can now reach most spots easily. This is having an impact of the local wildlife population, especially during the hunting season (usually in the winter months)

- **Presence of fish farms:** Presence of illegal fish farms in the area is a major threat for the Indian otter. Though the farms themselves provide habitat and food source to the otter, the owners of the farms claim that otters are a serious threat for their fish production so they kill this animal to protect their fish as well as selling the skin;

- **Threats to Feral donkey:** Trapping of asses of Achhro Thar for selling in the local markets is rapidly decreasing their population. It is not yet confirmed whether this animal is a feral donkey, wild ass or some other race or sub-species. There are chances of its being crossed with the Indian Wild Ass in Thar and Ran of Kutch as it has been in the wild since the last 70 years and sharing its habitat with the wild ass. Nevertheless, after spending many generations in the wild it should be treated as wildlife resource and not be exploited as it is now.

- **Killing of Caracals:** The Caracal is a critically endangered species in Pakistan (IUCN 2005) and a few animals (2-3) are have survived in the area. Killing of Caracals in Sona Jonejo which is the only place in Chotiari Reservoir where caracal exists will eliminate this species from Chotiari very soon if not protected.

- **Loss of habitat**: rising water levels are affecting the habitat in the immediate vicinity of the reservoir;

3.1.6.2 Recommendations

- **Controlled hunting:** Therefore, the check posts may be established at important points for keeping vigilance on uncontrolled hunting. The Sindh Wildlife Department is short of staff and transport to check the hunting pressure. The authority should consider strengthening of Sindh Wildlife Department in the area.

- **Development and maintenance of Sona Jonejo as a wildlife park:** Sona Jonejo, a private wildlife park established in early 1970's by Ex Game Warden Mr. Karim Daad Jonejo, is a beautiful and isolated island in Chotiari reservoir. It should be renovated and maintained with the cooperation of the owner's family and after the introduction of some animals especially Chinkara and Hog deer; this could also help promote eco-tourism in the area.

- **Discourage of persecution of otters in the area:** Though fish farms potentially provide habitat and a food source to otters; the animal is usually persecuted to extinction. Therefore owners of fish farms should be discouraged in the area as it poses threats to the Near Threatened (NT) species Indian otter. Fish farming is a source of livelihood for the local people but fish farms can be established anywhere outside the otter habitat. On the other hand, otters do not have vast and secure habitats to survive.

- **Community based conservation tourism:** Chotiari Reservoir is a good site for promoting ecotourism. The watch towers at potential points for birds watching; Wildlife Park at Sona Jonejo and other facilities need to be developed. The local community should be involved and benefited from this activity. This will provide incentives to the local community as an income generating activity and an alternative livelihood source.

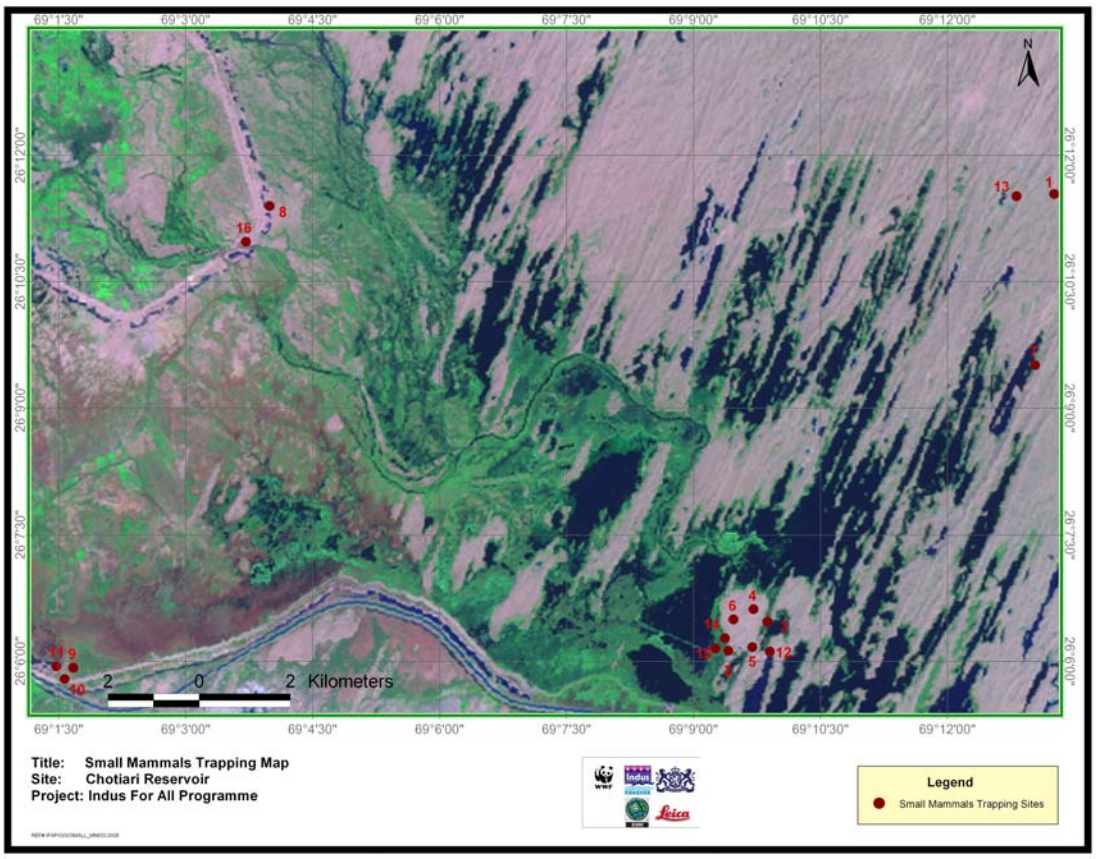
- **Promote participatory community wildlife management:** The institutional capacity of community based organizations in the area for wildlife management and conservation needs to be developed.

3.2 Small mammals

3.2.1 Sampling locations

Map 4 shows the sample locations for small mammals in Chotiari Reservoir. Details of the sampling points can be found in the annexure document.

Map 4 – Locations of sampling location for small mammals at Chotiari reservoir Reservoir



3.2.2 Species account

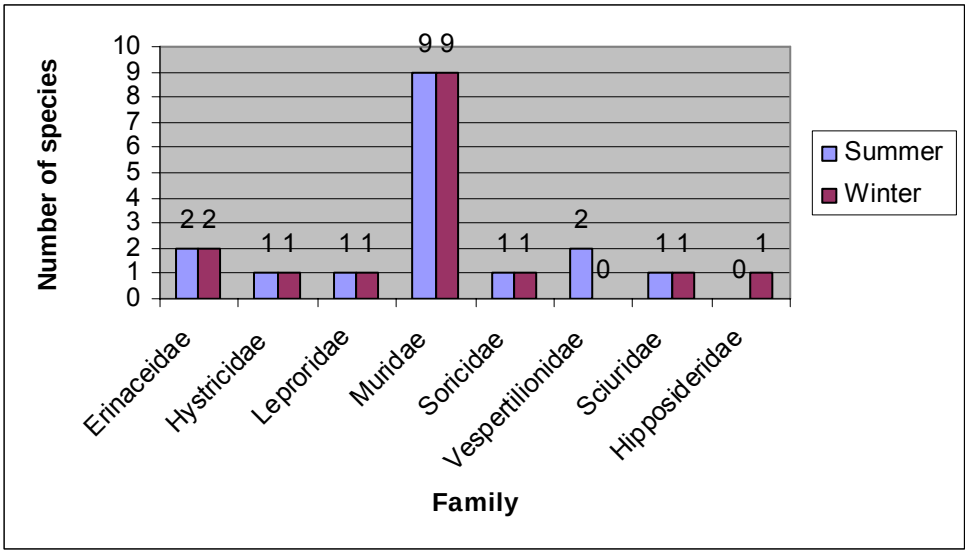
A total of 19 species were observed, 17 in summer and 16 in winter. The species were distributed over 4 orders (Rodentia, Insectivora, Lagamorpha and Chiroptera) and 8 families. **Table 11** gives an account of the species recorded at Chotiari Reservoir along with their conservation status, feeding habits and activity habits.

Table 11 – Total species recorded at Chotiari Reservoir along with conservation status, feeding habits and activity habits

	Scientific Name	English Name	Feeding Habit	Behaviour	Status	Summer	Winter
1	*Asellia tridens*	Leaf-nosed bat	INS	NC	LC	-	+
2	*Bandicota bengalensis*	Sindh Rice Rat	GRN	NC	C	+	+
3	*Funambulus pennantii*	Palm Squirrel	GRN	DR	C	+	+
4	*Gerbilus nanus*	Balochistan Gerbil	GRN	NC	C	+	+
5	*Hemiechinus collaris*	Long-eared Hedgehog	OMV	NC	LC	+	+
6	*Hystrix indica*	Indian crested porcupine	HRB	NC	C	+	+

7	*Lepus nigricolis*	Desert hare	HRB	NC	C	+	+
8	*Meriones hurrianae*	Indian Desert Jird	GRN	DR	LC	+	+
9	*Millardia gleadwi*	Sand coloured rat	GRN	NC	LC	+	-
10	*Millardia meltada*	Soft-furred field rat	GRN	NC	LC	+	+
11	*Mus booduga*	Little Indian field-mouse	GRN	NC	C	+	+
12	*Mus musculus*	House mouse	GRN	NC	C	+	+
13	*Nesokia indica*	Short-tailed rat	GRN	NC	C	-	+
14	*Paraechinus micropus*	Indian Hedgehog	INS	NC	C	+	+
15	*Pipistrellus kuhlii*	Kuhls' bat	INS	NC	C	+	-
16	*Rattus rattus*	Common Rat	OMV	NC	C	+	+
17	*Scotophilus heathii*	Common yellow-bellied bat	INS	NC	LC	+	-
18	*Suncus murinus*	House shrew	INS	NC	C	+	+
19	*Tatera indica*	Indian Gerbil	GRN	NC	C	+	+

Figure 1 – Family representation of recorded small mammals at Chotiari Reservoir



3.2.3 Habitats and feeding types

Chotiari Reservoir area contains diverse habitats such as open wetlands, shallow pools; aquatic margin vegetation, sand dunes and surrounding desert land provide shelter for variety small mammals. This is reflected by the number of species recorded both in summer and winter (only one family of the total recorded was absent in winter). As with most sites, *Muridae* was the most commonly represented family at Chotiari reservoir and the remaining families were represented by one or two species. **Figure 1** shows the number of number of species in each family

Most of the species at Chotiari Reservoir were recorded from sandy areas with one species being recorded near a water source and another (bat) species found roosting in a tree. Compared to other sites there was relatively less agriculture surveyed indicating that the species found in the sites are adapted to several habitats. **Figures 2** and **3** show the distribution of species over feeding habitats

and number of species recorded from the main habitats surveyed at Chotiari Reservoir.

Figure 2 – Distribution of feeding types across the species recorded at Chotiari Reservoir

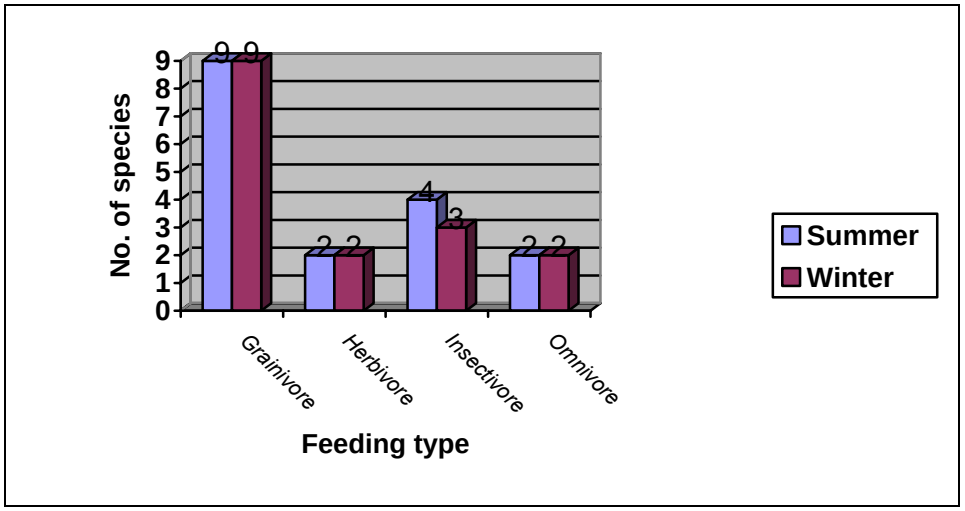
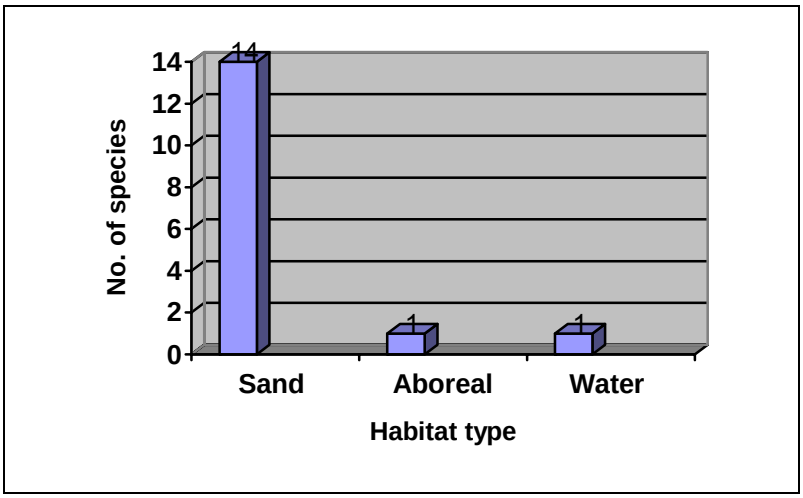


Figure 3 – Number of species recorded from main habitat types at Chotiari Reservoir



3.2.4 Threats and recommendations

3.2.4.1 Threats

- The construction of reservoir and the subsequent flooding of the reservoir have had an adverse impact on the micro-habitats of the area, undoubtedly affecting small populations either directly through loss of habitat or through the unbalancing of the ecosystem that is common after such major construction development. Secondly, the rising water levels are causing water-logging outside the reservoir embankments threatening many of the small mammals, most of which are borrowing species;

- Additional development such as the construction of nearby highways and roads are potential threats through habitat fragmentation. Without

purposely built under-road passes, some mammals populations species can become fragmented and face reproduction problems;

- Porcupine and hare hunting are a threat around the reservoir though less than other sites.

3.2.4.2 Recommendations

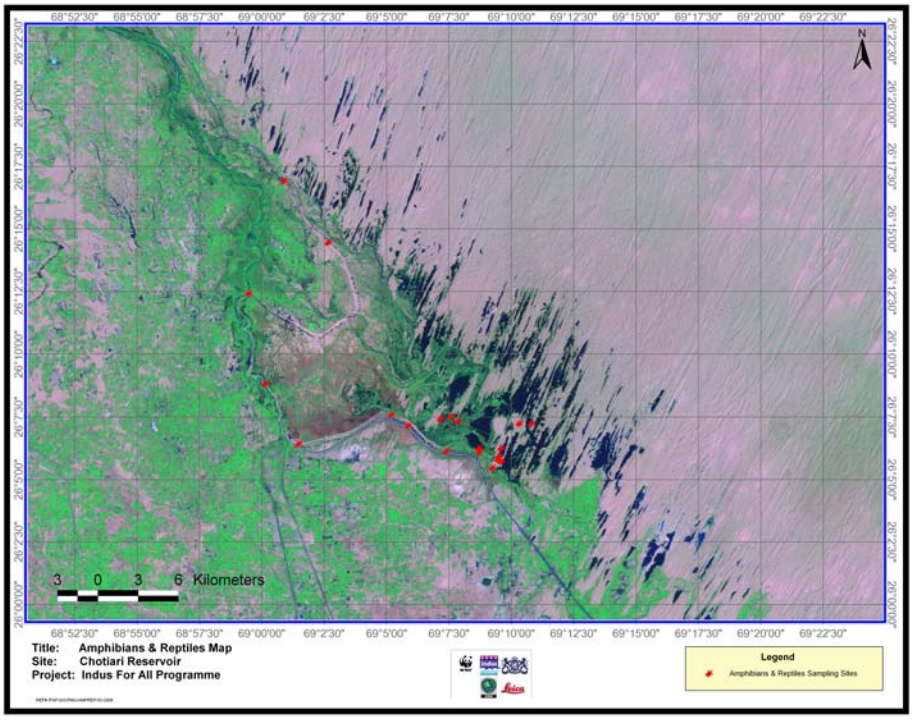
- The Sindh Wildlife Department should monitor local small mammal populations around the reservoir and develop guidelines and action plans for the managers of the water body (Sindh Irrigation and Drainage Authority);
- The Sindh Wildlife Department should strictly enforce the wildlife act and discourage the hunting of small mammals. Alternatively, community managed game reserves could be initiated and hunting of such species could be brought under licensing controlled by the local communities which in turn with provide financial incentives for community to protect wildlife.

3.3 Reptiles and Amphibians

3.3.1 Sample points

Map 5 shows the location of samples for reptile and amphibian trapping from Chotiari Reservoir.

Map 5 – Sampling points of reptile and amphibian surveys at Chotiari Reservoir



3.3.2 Summary

The Chotiari Reservoir can be delineated into four distinct habitats viz. Desert scrub, Sand dunes, Riverine forest and the proper reservoir area and its associated small natural lakes (Dhands), each with its specific flora and fauna.

The Riverine forest is dominated by *Populus euphratica, Dalbergia sissoo, Prosopis cineraria, Acacia nilotica* and *Zizyphus mauritiana* while the vegetation in sand dunes and desert scrub includes *Calotropis procera, Capparis decidua, Salvadora oleoides, Crotolaria burhea, Alhaji maurorum* and *Calligonum polygonoides.* Aquatic vegetation of the reservoir comprises of *Typha latifolia, T. angustata, Phragmites karka, Ipomoea aquatica, Nymphaea lotus, Nelumbo nucifera, Polygonum* spp., *Urticularia lotus* and *Saccharum spontaneum.*

Several villages and small islands were surveyed from 17 to 20 June and 14 to 16 November 2007 for the presence of amphibians and reptiles. The outside areas of the reservoir which were surveyed included: Khair Muhammad Junejo, Ali Bakhsh Goth, Bakar Pathan, Jalal, Henro in Sari Lake, Goth Mohammad Hassan Hingharo, Zero Point, Goth Maula Bakhsh Behan, Makhdoom of Haala area, Muhammad Usman Ibuppoto, Akhanwari pumping station, Paksari, Noon Gharo Lake and Ranto Canal. The islands inside the reservoir were also surveyed to maximize the observation and collection including Saddori Bit, Sabir Jee Darro, Korrki, Phulail, Urs Junejo and Ludhi-waro Dharro. Both day and night surveys were conducted in four of the delineated habitats of the reservoir and all possible methods were employed to collect amphibians and reptiles.

At one site, RD-174 or D-8, the area is perhaps a representative habitat of sand dunes, which is more suitable for the pitfall traps. The author, therefore, installed pitfall trap (N 26° 07′ .234″, E 69° 08′ .657″) for three days in the summer season. This method proved to be the most successful and a large number of lizards and some colubrid snakes were collected. Due to the beginning of hibernation period of the amphibians and reptiles, there are minimal activities during winter; hence the pitfall traps were not placed in November surveys.

Chotiari Reservoir has a great significance pertaining to the natural history of herpeto-fauna. There is a handsome natural population of Marsh Crocodile (*Crocodylus palustris*) in the Nara Canal and other sites inside Chotiari reservoir (Hafeez, 2006) area. Chotiari reservoir with the population of crocodiles as reported by Hafeez (2006) could possibly prove to be one of the largest reservoirs of crocodiles in Pakistan. The presence of Rock Python (*Python molurus*) is also suggestive of the importance of this reservoir. The Rock Python is not only reported by the earlier herpetologists but also the local inhabitants claim for its definite presence. The status, distribution and other details of these two key species of reptiles are discussed in detail in the species account section. Though, the author did not observed rock python in both the summer and winter studies, yet there is a need of consistent monitoring of the area for this species. During the winter studies, though the activities of the herpetiles were not highly evident, yet a large number of herpetiles were observed and collected.

The summer studies resulted into the collection/confirmation of 28 species of amphibians and reptiles out of 58 species possibly occurring in the area (28 species being observed or collected by the author and his team and the remaining were identified by the local inhabitants after thorough discussion as well as by earlier literature citations). In the winter studies, more areas were surveyed, which resulted in the observation and collection of 3 additional species i.e. two species of freshwater turtles i.e. *Kachuga tecta* and *Lissemys punctata andersoni* and a lacertid *Mesalina watsonana*, thus making the total number of herpetiles as 31. The amphibians are represented by 3 species belonging to 3 genera and 2 families. Among the reptiles, chelonians are represented by 9 species belonging to 7 genera and 3 families. A single species of Marsh Crocodile belonging to family crocodylidae is also present. Lizards are the second

dominant group of herpetiles in the study area, represented by 20 species belonging to 15 genera and 7 families. Snakes outnumber all the groups of reptiles and are represented by 25 species belonging to 18 genera and 6 families.

Image 7 – Typical habitat near the banks of Chotiari Reservoir

Image 8 – Trapping nets places near the banks of Chotiari Reservoir

Image 9 – Reptile and amphibian habitat near Chotiari Reservoir

Image 10 – View of one of the water bodies that makes up Chotiari Reservoir

3.3.3 Species account for summer and winter

In **Table 12**, it is evident that the observation or collection of various herpetiles is pronounced and diverse in the summer season as compared to the pre-winter studies. The higher richness, Shannon and Margalef indices of biodiversity during summer also support this statement with the values of 28, 2.652 and 3.866 respectively. The evenness is relatively higher in the winter studies. This however is not a prominent reflector of higher diversity.

Table 12 – Comparison of amphibian and reptilian diversity during summer and pre-winter studies at Chotiari Reservoir

S. No.	Species Name	Total	Summer	Winter
1	*Bufo stomaticus*	139	125	14
2	*Euphlyctis c. cyanophlyctis*	47	47	0
3	*Hoplobatrachus tigerinus*	33	27	06
4	*Crocodylus palustris*	100	100***	0

S. No.	Species Name	Total	Summer	Winter
5	*Kachuga tecta*	14	0	14
6	*Kachuga smithii*	66	49	17
7	*Geoclemys hamiltonii*	30	17	13
8	*Lissemys punctata andersoni*	04	0	04
9	*Aspideretes gangeticus*	08	08	0
10	*Eublepharis macularius*	13	13	0
11	*Uromastyx hardwickii*	11	11	0
12	*Calotes v. versicolor*	12	09	03
13	*Trapelus megalonyx*	07	07	0
14	*Trapelus agilis pakistanensis*	09	02	07
15	*Crossobamon orientalis*	141	125	16
16	*Cyrtopodion scaber*	12	12	0
17	*Hemidactylus flaviviridis*	42	34	08
18	*Acanthodactylus cantoris*	230	145	85
19	*Eremias cholistanica*	15	15	0
20	*Mesalina watsonana*	04	0	04
21	*Ophiomorus tridactylus*	271	173	98
22	*Varanus bengalensis*	65	26	39
23	*Platyceps v. indusai*	04	04	0
24	*Eryx johnii*	08	08	0
25	*Eryx conicus*	04	04	0
26	*Ptyas m. mucosus*	09	09	0
27	*Xenochrophis c. cerasogaster*	02	02	0
28	*Bungarus c. caeruleus*	03	03	0
29	*Naja n. naja*	06	05	01
30	*Echis carinatus sochureki*	122	96	26
31	*Daboia russelii*	04	04	0
	Total (number of individuals collected)	1435	1080	355

***= The number is indicative of Crocodiles being reported by Dr. Hafeez (2006) in his preliminary baseline survey report

3.3.4 Species evenness and diversity

Table 13 shows the species richness (number of species), evenness and two indexes (Simpson's and Margalef). **Figures 4** to **6** graphically show the results of species richness, evenness and diversity indexes.

Table 13 – Showing species richness, evenness, Simpson's and Margalef indexes

S.no	Index types	Summer	Winter
1	Richness (number of species)	28	16
2	Evenness	0.5063	0.5545
3	Shannon Index	2.652	2.554
4	Margalef Index	3.866	3.342

Figure 4 – Number of reptile and amphibian species recorded at Chotiari Reservoir during summer and winter surveys.

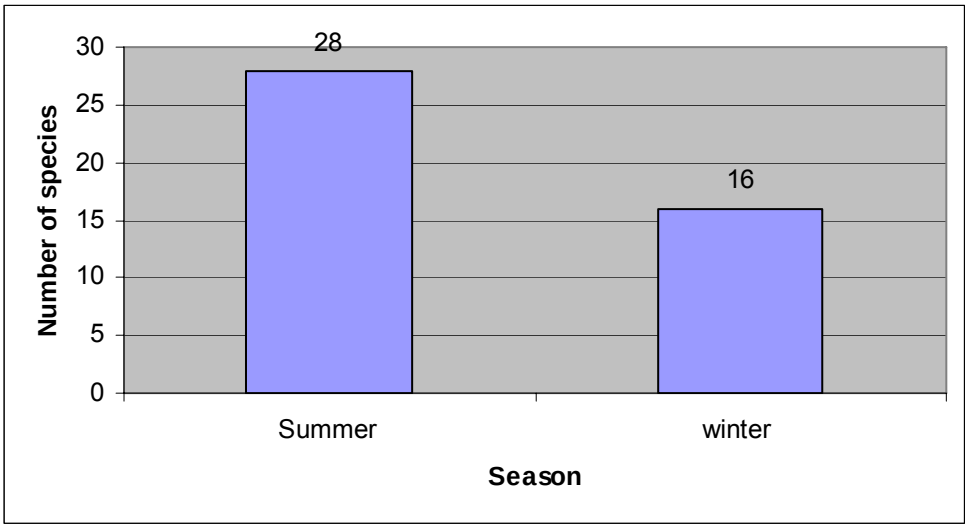


Figure 5 – Species evenness of species recorded from Chotiari Reservoir

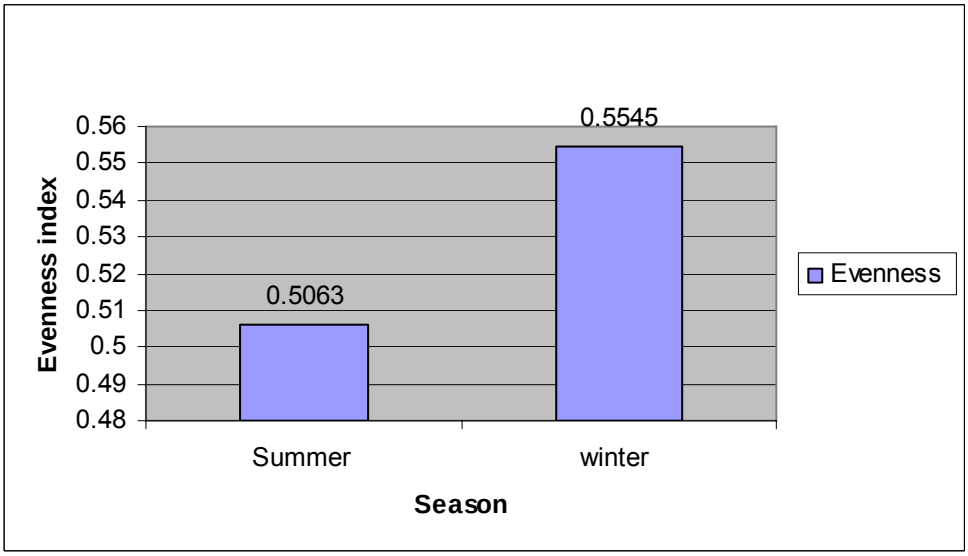
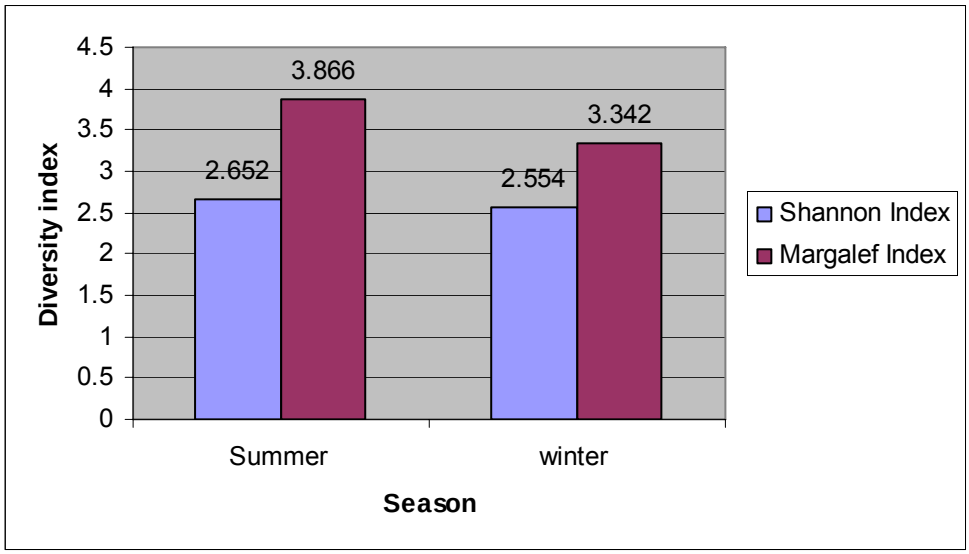


Figure 6 – Simpson's and Margalef's index



There was nearly double numbers of species in summer than winter (28 in summer and 16 in winter) which is expected given that many of the reptile and amphibian species go into hibernation.

Looking at the evenness, there is a big difference between summer and winter. Again this is to be expected given the tendencies of many reptile and amphibian to hibernate in winter. It can be inferred that in summer, though there are more species there are several species with over 100 captured animal's against the average of 32 animals per species. In winter there are less species but more homogeneity in the number of animals captures.

Finally coming to the species richness index, Margalef gives nearly equal index for summer and winter, whereas Shannon gives a higher index in summer since this equations takes into account evenness unlike the Margalef index. However, there is no marked difference in summer and winter indicating that some populations are pretty much self regulating.

3.3.5 Threats and recommendations

3.3.5.1 Threats

- Local communities use the reservoir area for livestock grazing and irrigated agriculture hence disturbing the natural ecosystem for the herpetiles;
- Due to indiscriminate use of fishing gears, a large number of accidental entanglements of freshwater turtles take place. This phenomenon is disturbing the natural population of highly valuable internationally protected freshwater turtle species;
- Some of the locals are involved in hunting the endangered crocodile and python species for their skins thus reducing their population. Similarly the local physicians called "Hakims" are extensively depleting the herpetofauna by using the parts of Spiny tail ground lizard, Common mole skink, Orange-tailed skink and Sand-swimmers;
- The local communities have apprehensions about the lizards and snakes, especially crocodiles and pythons, due to their large sizes. They are regarded as their enemies and are killed on sight if encountered;

- There are a large number of road-kills of Monitor lizard and Spiny-tailed lizard species due to over-speeding of vehicles around the reservoir area. These species are on the protected list of IUCN and CITES and thus need immediate attention for conservation.

3.3.5.2 Recommendations

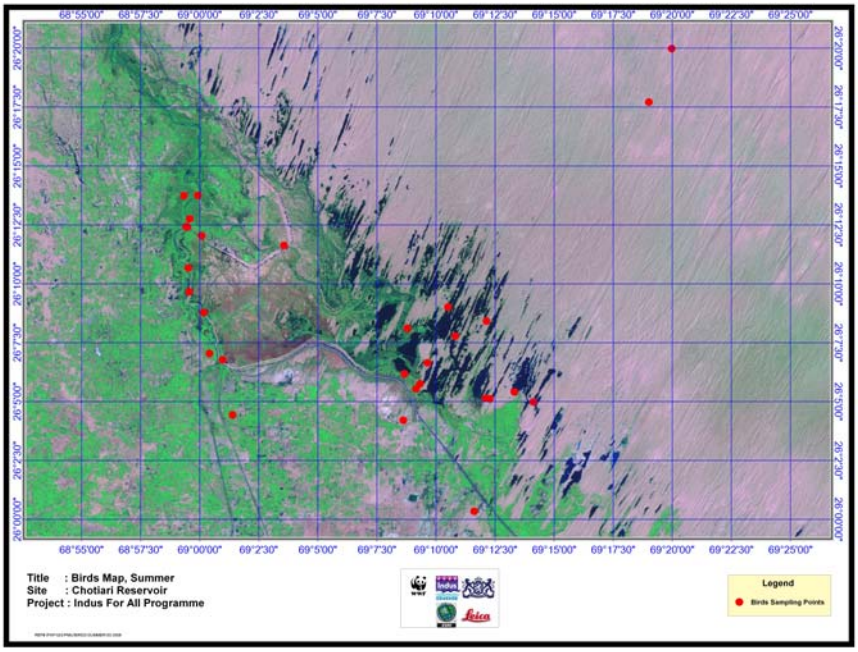
- The local communities and the wildlife staff should be educated about the importance of amphibian and reptilian fauna in the reservoir ecosystem through trainings, workshops, pamphlets and brochures;
- A crocodile breeding and research center should be established in the area to initiate research on various aspects of its biology;
- The reservoir presents ideal conditions for the freshwater turtle population. There is a need to establish a center for breeding of endangered and economically important freshwater turtles including Indian soft-shell and Narrow-headed soft-shell turtles;
- There should be a complete ban on the collection of reptiles for un-scientific purposes including its illegal trade;
- Signboards should be placed on the roads, highlighting the nearby heavily populated amphibian or reptile species and the speed of vehicles must remain within limits accordingly.

3.4 Avifauna

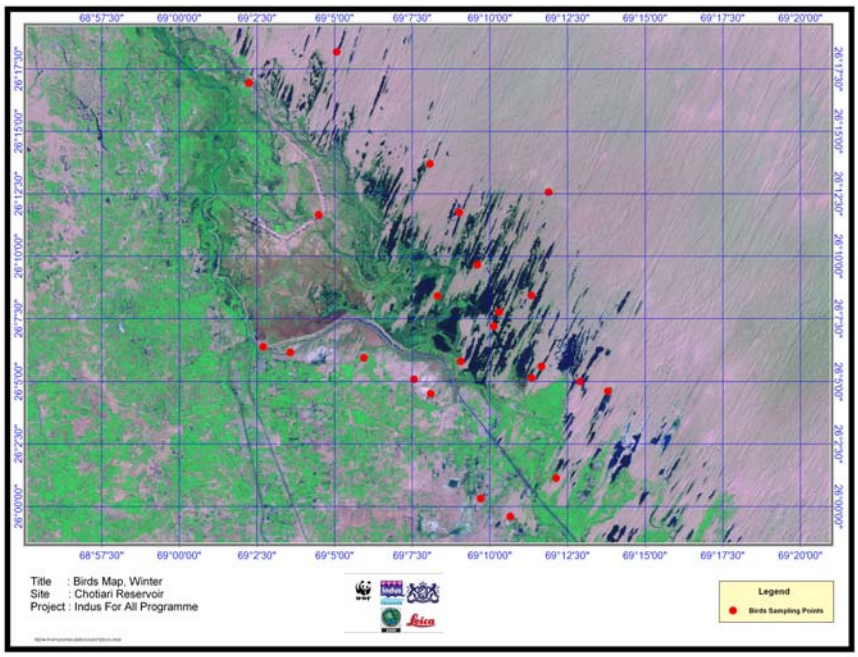
3.4.1 Sampling points

Maps 6 and **7** show the sampling points for bird surveys in Chotiari Reservoir over summer and winter. Details of the sampling points can be found in the annexure document.

Map 6 – Sampling points of bird surveys during summer



Map 7 – Sampling points of bird surveys during winter



3.4.2 Summary

Chotiari Reservoir has diverse habitats for birds, which includes lakes, swamps, marshes and reed beds having somewhat dense vegetation cover, irrigation canals, riverine forest, cultivated land and desert/semi-desert area. The area provides suitable habitat for a wide variety of birds. As many as 109 species of birds have been recorded from the area (Ghalib et al 1999).

Chotiari Reservoir is the biggest reservoir in Thar Desert covers the area about 44,000 acres. The reservoir was formed by the construction of bund in Northern and western sides are included. The reservoir is filled by "Ranto Canal", the sub-canal of Nara Canal arises from Head Jamrao. Nara Canal arises from Sukkur Barrage (River Indus). Rain water is also an important source of water for the reservoir. The main objective of the reservoir is to provide water supply to the lower plain areas of Sindh and during shortage of water in the Indus during winter season; water is supplied through Nara Canal. Seepage water forms several lakes like reservoirs in between the sand dunes and several small lakes were formed because of the formation of water reservoirs flora is increasing, fish population is also increasing.

A total of 80 species of birds were recorded in the summer surveys while 72 species were recorded in the winter surveys.

3.4.3 Species account

3.4.3.1 Summer

Table 14 shows the birds species observed at Chotiari reservoir during summer.

Table 14 – List of bird species recorded from Chotiari Reservoir

	English name	*Scientific name*	Status	Occurrence	Count
1	Little Grebe	*Tachybatus ruficollis*	Common	Resident	57
2	Little cormorant	*Phalacrocorax niger*	Common	Resident	196
3	Yellow bittern	*Ixobrychus sinensis*	Common	Resident	05
4	Cinnamon bittern	*Ixobrychus cinnamomeus*	Scarce	Resident	1
5	Black bittern	*Ixobrychus flavicollis*	Scarce	Resident	1
6	Indian pond heron	*Ardeola grayii*	Common	Resident	120
7	Cattle egret	*Bubuleus ibis*	Common	Resident	206
8	Little egret	*Egretta garzette*	Common	Resident	320
9	Intermediate egret	*Egretta intermedia*	Scarce	Resident	100
10	Grey heron	*Ardea cinerea*	Common	Resident	59
11	Purple heron	*Ardea purpurea*	Scarce	Resident	25
12	Glossy ibis	*Plegadis falcinellus*	Scarce	Resident	13
13	Pallas's fish-eagle	*Haliaeetus leucoryphus*	Rare	Summer visitor	01
14	Black-shouldered Kite	*Elanus caeruleus*	Scarce	Resident	04
15	Shikra	*Accipiter badius*	Scarce	Resident	02
16	White-eyed buzzard	*Butastur teesa*	Scarce	Resident	05
17	Black partridge	*Francolinus francolinus*	Scarce	Resident	09
18	Indian grey partridge	*Francolinus pondicerianus*	Scarce	Resident	07
19	White-breasted water-hen	*Amaurornis phoenicurus*	Scarce	Resident	04
20	Common moorhen	*Gallinula chloropus*	Scarce	Resident	03
21	Purple gallinule	*Porphyrio purphyrio*	Scarce	Resident	04
22	Watercock	*Gallicrex cinerea*	Rare	Summer breeder	01

23	Pheasant tailed-jacana	*Hydrophasianus chirurgus*	Scarce	Resident	09
24	Black-winged stilt	*Himantopus himantopus*	Common	Resident	34
25	Red-wattled lapwing	*Hoplopterus indicus*	Common	Resident	130
26	White-tailed lapwing	*Chettusia leucura*	Common	Winter visitor	29
27	Greenshank	*Tringa nebularia*	Scarce	Winter visitor	02
28	Gull-billed Tern	*Gelochelidon nilotica*	Common	Winter visitor	10
29	Indian river tern	*Sterna aurentia*	Common	Summer breeder	56
30	Little tern	*Sterna albifrons*	Common	Summer visitor	32
31	Chestnut-bellied sand grouse	*Pterocles exustus*	Scarce	Resident	06
32	Blue rock pigeon	*Columba liva*	Common	Resident	132
33	Collared dove	*Streptopelia decaocto*	Common	Resident	101
34	Red turtle dove	*Streptopelia tranquebarica*	Scarce	Summer visitor	22
35	Little brown dove	*Streptopelia senegalensis*	Common	Resident	138
36	Rose-ringed parakeet	*Psittacula krameri*	Common	Resident	79
37	Pied crested cuckoo	*Clamator jacobinus*	Scarce	Summer breeder	04
38	Common koel	*Eudynamys scolopacea*	Common	Summer breeder	02
39	Common crow pheasant	*Centropus sinensis*	Common	Resident	64
40	Barn owl	*Tyto alba*	Rare	Resident	01
41	Spotted owlet	*Athene brama*	Common	Resident	09
42	Sindh Nightjar	*Caprimulgus mahrattensis*	Common	Resident	92
43	White breasted kingfisher	*Halcyon smyrnensis*	Common	Resident	05
44	Common kingfisher	*Alcedo atthis*	Common	Resident	07
45	Pied kingfisher	*Ceryle rudis*	Common	Resident	32
46	Little green Bee-eater	*Merops orientalis*	Common	Resident	72
47	Blue cheeked bee-eater	*Merops superciliosus*	Scarce	Summer breeder	68
48	Indian roller	*Coracias benghalensis*	Common	Resident	22
49	Lesser golden-backed wood pecker	*Dinopium benghalensis*	Common	Resident	08
50	Ashy-crowned finch-lark	*Eremopterix grisea*	Common	Resident	28
51	Crested lark	*Galerida cristata*	Common	Resident	61
52	Small Skylark	*Alauda gulgula*	Common	Resident	101
53	Plain sand martin	*Riparia paludicola*	Common	Resident	1137
54	Barn Swallow	*Hirundo rustica*	Common	Winter visitor	1095
55	Wire-tailed swallow	*Hirundo smithi*	Common	Resident	08
56	White-browed wagtail	*Motacilla maderaspatensis*	Scarce	Resident	03
57	White-cheeked Bulbul	*Pycnonotus leucogenys*	Common	Resident	13
58	Red-vented bulbul	*Pycnonotus cafer*	Scarce	Resident	04
59	Pied-bush chat	*Saxicola caprata*	Common	Resident	56
60	Indian robin	*Saxicoloides fulicata*	Common	Resident	19
61	Graceful Prima	*Prinia gracilis*	Common	Resident	19
62	Rufous fronted prinia	*Prinia buchanani*	Common	Resident	10

63	Plain Prinia	*Priniainornata*	Common	Resident	21
64	Common babbler	*Turdoides caudatus*	Common	Resident	99
65	Jungle babbler	*Turdoides striatus*	Common	Resident	22
66	Purple sunbird	*Nectarinia asiatica*	Common	Resident	29
67	Bay-backed shrike	*Lanius vittatus*	Scarce	Resident	06
68	Long tailed shrike	*Lanius schach*	Common	Resident	09
69	Great grey shrike	*Lanius excubitor*	Common	Summer breeder	08
70	Black drongo	*Dicrurus macrocercus*	Common	Resident	31
71	Indian tree-pie	*Dendrocitta vagabunda*	Common	Resident	04
72	Indian house crow	*Corvus splendens*	Common	Resident	413
73	Common starling	*Sturnus vulgaris*	Common	Resident	10
74	Common myna	*Acridotheres tristis*	Common	Resident	42
75	Bank myna	*Acridotheres ginginianus*	Common	Resident	341
76	Indian house sparrow	*Passer domesticus*	Common	Resident	260
77	Sindh jungle sparrow	*Passer pyrrhonotus*	Scarce	Resident	06
78	Yellow throated sparrow	*Petronia xanthocollis*	Common	Spring migrant	44
79	Black crowned night heron	*Nycticorax nycticorax*	Scarce	Resident	45
80	Paddy field pipit	Anthus rufulus	Scarce	Summer breeder	06
Total					6271

3.4.3.2 Winter

Table 15 shows the list of bird species found at Chotiari Reservoir during winter

Table 15 – List of bird species recorded from Chotiari Reservoir during winter

S. No.	Common Name	Scientific Name	Status	Occurrence	Count
1.	Little grebe	*Tachybaptus ruficollis*	Common	Resident	138
2.	Great cormorant	*Phatacrocorax carbo*	Common	Winter Visitor	138
3.	Little cormorant	*Phalacrocorax ringer*	Common	Resident	104
4.	Indian pond heron	*Ardeola grayii*	Common	Resident	25
5.	Black crowned night heron	*Nycticorax nycticoroax*	Less Common	Resident	05
6.	Little egret	*Egretta garzetta*	Less Common	Resident	29
7.	Intermediate egret	*Merophoyx intermedia*	Less Common	Resident	117
8.	Great white egret	*Casmerodius alba*	Common	Winter Visitor	183
9.	Grey heron	*Ardea cinerea*	Common	Winter Visitor	121
10.	Purple heron	*Ardea purpurea*	Scarce	Year Round Visitor	02
11.	Glossy ibis	*Plegadis falcinellus*	Scarce	Year Round Visitor	09
12.	Greater white fronted	*Anser albifrons*	Rare	Vagrant	02

	goose				
13.	Gadwall	*Anas strepera*	Common	Winter Visitor	17
14.	Common teal	*Anas crecc*	Common	Winter Visitor	295
15.	Mallard	*Anas platyrhynchos*	Less Common	Winter Visitor	03
16.	Northern pintail	*Anas acuta*	Common	Winter Visitor	25
17.	Northern shoveler	*Anas clypeata*	Common	Winter Visitor	25
18.	Red-crested pochard	*Netta rufina*	Rare	Winter Visitor	01
19.	Common pochard	*Aythya ferina*	Common	Winter Visitor	38
20.	Tufted duck	*Aythya fuligula*	Common	Passage Migrant	19
21.	Black shouldered kite	*Elanus caeruleus*	Less Common	Resident	04
22.	Pallas's fish eagle	*Haliaeetus leucoryphus*	Scarce	Resident	02
23.	Marsh harrier	*Circus aeruginosus*	Common	Winter Visitor	24
24.	Common buzzard	*Buteo buteo*	Scarce	Winter Visitor	01
25.	Long-legged buzzard	*Buteo rufinus*	Scarce	Winter Visitor	02
26.	Osprey	*Pandion haliaetus*	Less Common	Winter Visitor	04
27.	White-breasted water hen	*Amaurornis phoenicurus*	Common	Resident	22
28.	Common moorhen	*Gallinula chloropus*	Common	Resident	64
29.	Purple gallinule	*Porphyrio porphyrio*	Less Common	Resident	03
30.	Common coot	*Fulica atra*	Common	Winter Visitor	472
31.	Black-winged stilt	*Himantopus himantopus*	Common	Resident	15
32.	Red-wattled lapwing	*Hoplopterus indicus*	Common	Resident	33
33.	White-tailed lapwing	*Chettusia leucura*	Less Common	Winter Visitor	06
34.	Little stint	*Calidris minuta*	Common	Winter Visitor	248
35.	Red shank	*Tringa tetanus*	Common	Winter Visitor	27
36.	Wood sandpiper	*Tringa glareola*	Scarce	Winter Visitor	03
37.	Great black-headed gull	*Larus ichthyaetus*	Common	Winter Visitor	41
38.	Black-headed gull	*Larus ridibundus*	Common	Winter	187

				Visitor	
39.	Herring gull	*Larus argentatus*	Common	Winter Visitor	53
40.	Indian river tern	*Sterna aurantia*	Common	Winter Visitor	75
41.	Whiskered tern	*Chlidonias hybridus*	Common	Winter Visitor	13
42.	Indian collared dove	*Streptopelia decaocto*	Common	Resident	128
43.	Little brown dove	*Streptopelia senegalensis*	Common	Resident	44
44.	Common crow pheasant	*Centropus sinensis*	Less Common	Resident	07
45.	White-throated kingfisher	*Halcyon smyrnensis*	Common	Resident	16
46.	Lesser pied kingfisher	*Ceryle rudis*	Common	Resident	20
47.	Hoopoe	*Upupa epops*	Common	Winter Visitor	11
48.	Ashy-crowned finch lark	*Eremopterix grisea*	Common	Resident	12
49.	Crested lark	*Galerida cristata*	Less Common	Resident	08
50.	Plain sand martin	*Riparia paludicola*	Common	Resident	385
51.	Common swallow	*Hirundo rustica*	Common	Winter Visitor	117
52.	Yellow wagtail	*Motacilla flava*	Less Comm.	Winter Visitor	04
53.	Large pied wagtail	*Motacilla maderaspatensis*	Less Common	Winter Visitor	10
54.	White-cheeked bulbul	*Pycnonotus leucogenys*	Common	Resident	14
55.	Blue-throat	*Luscinia svecica*	Common	Winter Visitor	12
56.	Black redstart	*Phoenicurus ocruros*	Common	Winter Visitor	25
57.	Pied bush-chat	*Saxicola caprata*	Common	Resident	11
58.	Desert wheatear	*Oenanthe deserti*	Scarce	Winter Visitor	02
59.	Cetti's bush warbler	*Cettia cetti*	Scarce	Winter Visitor	04
60.	Plain-coloured prinia	*Prinia inornata*	Scarce	Resident	04
61.	Lesser whitethroat	*Sylvia curruca*	Common	Winter Visitor	11
62.	Brown chiffchaff	*Phylloscopus collybita*	Common	Winter Visitor	23
63.	Common babbler	*Turdoides caudatus*	Common	Resident	16
64.	Striated babbler	*Turdoides earlei*	Common	Resident	11
65.	Purple sunbird	*Nectarinia asiatica*	Less Common	Resident	08
66.	Bay-backed Shrike	*Lanius vittatus*	Scarce	Resident	02

67.	Black Drongo	*Dicrurus macrocercus*	Common	Resident	14
68.	Indian tree-pie	*Dendrocitta vagabunda*	Less Common	Resident	03
69.	Indian house crow	*Corvus splendens*	Common	Resident	179
70.	Common myna	*Acridotheres tristis*	Common	Resident	08
71.	Bank myna	*Acridotheres ginginianus*	Common	Resident	18
72.	Indian house sparrow	*Passer domesticus*	Abundant	Resident	355

Image 11 – Indian grey partridge at Chotiari Reservoir

Image 12 – White-winged lapwing at Chotiari Reservoir

3.3.4 Summer and winter comparison

The summer surveys in the area were undertaken during June 2007 and January 2008. **Figure 7** shows that the number of species collected was higher in the summer than in the winter (as were the families and orders). **Figure 8** shows that there were an equal number of resident as well as winter visitors recorded during the winter survey. As expected, in summer most of the species recorded were resident birds with a few migratory species.

Figure 7 – Number of species, families and orders recorded during summer and winter season

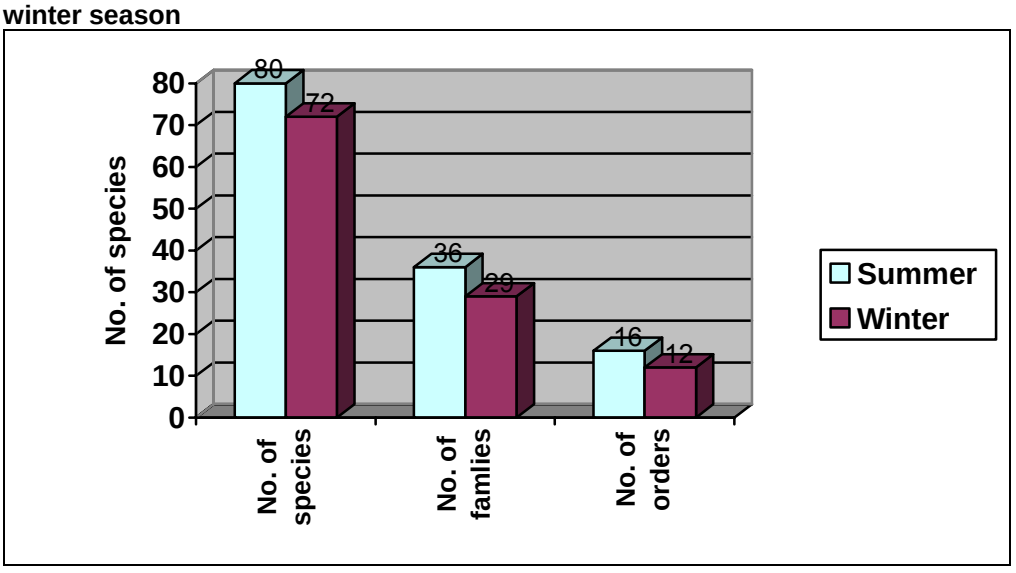
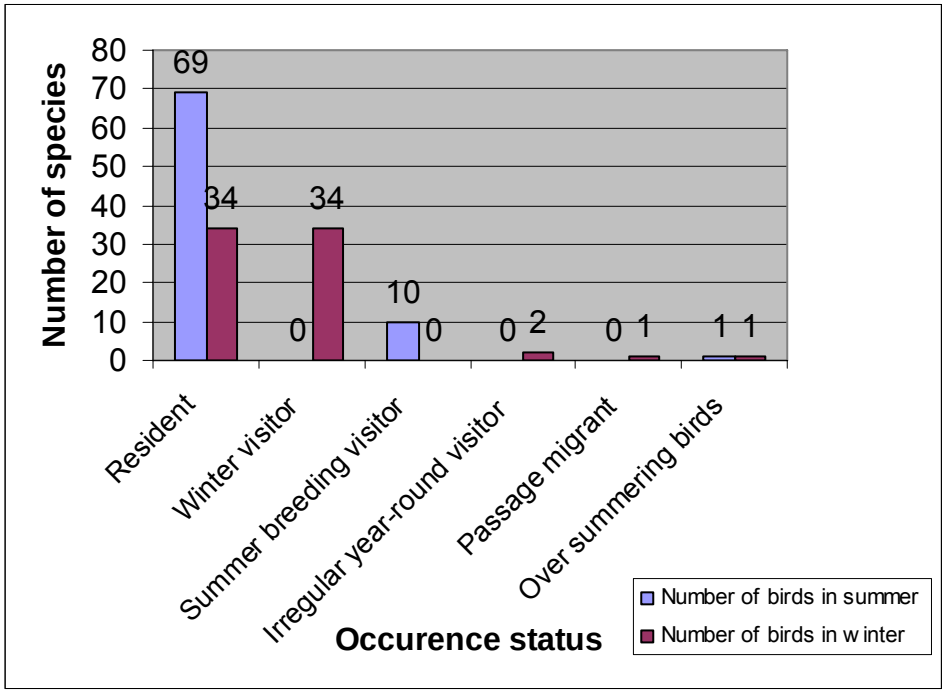


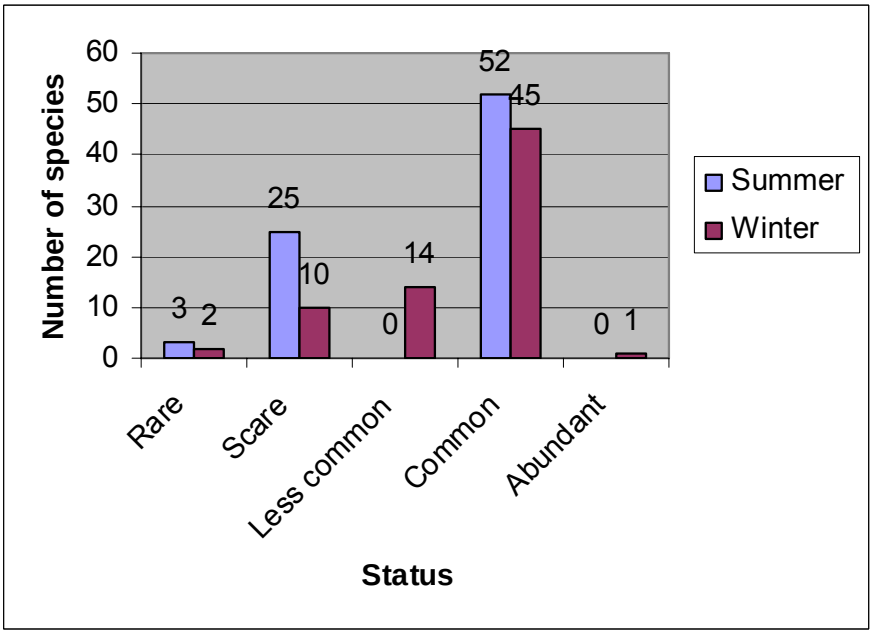
Figure 8 – Species occurrence in Chotiari Reservoir showing seasonal status of birds



3.4.5 Conservation status

Figure 9 shows the distribution of bird species over status at Chotiari Reservoir in summer and winter. Most species were common, especially in summer. There were quite a few species that were classified in summer which were absent in winter.

Figure 9 – Species abundance during summer and winter season.



3.4.6 Habitat

The habitat around the reservoir is ideal for water birds and a better shelter for wild animals. The reservoir has a number of benefits as well as negative effects. Because of desert sand, the seepage water is entering agricultural land. This seepage water is increasing water logging and salinity, causing the land to become infertile. In many places the desert has been converted into wetlands.

Three types of habitats have been formed:

i) Desert habitat
ii) Wetland habitat
iii) Agriculture habitat

There are certain species of birds of particular importance viz. Marbled Teal *(Marmaronetta angustirostris),* Jerdon's/Sind Babbler *(Moupinia altirostre),* Pallas's Fishing Eagle *(Haliaeetus leucorhyphus),* White Backed Vulture, Saker Falcon, Partridges, Water Cock, Wood Sandpiper, Knot, Ruff, Painted Snipe and Cliff Swallow.

3.4.7 Threats and recommendations

3.4.7.1 Threats

- Hunting is the main threat to the birds, especially in winter when hunters target migratory birds;

- Removal of habitat, both aquatic and terrestrial (especially forest) is also a major threat that removes potential nesting habitat as well as food source. One example of this is the removal of mature trees along some of the embankments which are host to a number of species that nest and feed in these trees.

- There are more than six main wetlands in the adjoining area of Chotiari Reservoir namely Sadori Lake, Sanghriaro Lake, Rarr Lake, Ithpar Lake, Nogharoon Lake and Panihal Lake. Chotiari Reservoir along-with these lakes forms a wetlands complex which is very important for supporting large concentrations of migratory water birds during the season. Despite this, these areas have no protection status such as wildlife sanctuary or Ramsar site.

3.3.7.2 Recommendations:

- Studies may be undertaken to locate the breeding areas of Marbled teal, Spot-bill duck, and whistling teal;

- Chotiari reservoir areas should be developed as protected area or community based conservation area;

- Ingenious species of trees may be grown along the bund and on inner islands to provide favorable habitat to the birds;

- There is a need to create public awareness about wildlife conservation in the communities. One way to do this is to erect sign boards and notice boards about the conservation of wild animals should be placed on public places and roads.

3.5 Fisheries

3.5.1 Species account

During the survey of Chotiari Reservoir a total of 47 species of fish were recorded from 9 Orders and 14 families. **Table 16** below shows the list of species recorded along with their associated feeding habits, habitats, size and commercial value.

Table 16 – Ecological and economic aspects of fish fauna of Chotiari Reservoir

S	Species	Feeding habit	Habitat	Max. size (cm)	Commercial value
1	*Gudusia chapra*	Aquatic insects, zooplanktons	Middle and upper reaches of rivers	20	Low
2	*Chitala chitala*	Aquatic insects, mollusks, shrimps and small fishes	Freshwater rivers, lakes	120	High
3	*Notopterus notopterus*	Insects, fish, crustaceans	Standing and sluggish waters of lakes, floodplains, canals and ponds	25	Low
4	*Chela cachius*	Insect larvae and plant matter	Ponds, ditches and rivers	6	Low
5	*Salmophasia bacaila*	Larvae and adults of insects	Slow running streams, rivers, ponds	15	Low
6	*Securicula gora*	Insects, insect larvae and crustaceans	Rivers and canals	22	Low
7	*Amblypharyngodon mola*	Insects, insect larvae and crustaceans	Ponds, canals, slow-moving streams, nullahs and paddy fields	20	Low
8	*Aspidoparia morar*	Phytoplanktons, insect larvae	Streams and ponds	17	Low
9	*Barilius vagra*	Phytoplanktons, insect larvae	Hill streams with gravelly and rocky bottom	12	Low
10	*Esomus danricus*		Ponds, weedy ditches	9	Low
11	*Rasbora daniconius*	Aquatic insects and detritus.	Ditches, ponds, canals, haors, streams, rivers	15	Low
12	*Cirrhinus mrigala*	Juvenile omnivorous, adults herbivorous, feeds on plankton, but also grazes on algae	Rivers, lakes	100	Very high

13	*Cirrhinus reba*	Planktons, insect, plant material	Rivers, lakes, canals	30	Fairly good
14	*Gibelion catla*	Aquatic and terrestrial insects, detritus and phytoplankton	Rivers, lakes	180	Very high
15	*Labeo calbasu*	Filamentous algae and diatoms	Slow-moving waters of rivers and ponds	90	High
16	*Labeo dero*	Filamentous algae, diatoms and phytoplankton's	Shallow and slow moving waters of rivers	60	Fairly good
17	*Labeo dyocheilus pakistanicus*	Omnivorous fish depending upon phytoplankton's, zooplanktons and larvae of aquatic insects	Active currents of large rivers	90	Fairly good
18	*Labeo gonius*	Plants, benthic algae, weeds	Rivers and lakes	150	Fairly good
19	*Labeo rohita*	Feeds on algae, Phytoplankton	Rivers and lakes	200	Very high
20	*Osteobrama cotio*	Feeds on aquatic insects	Rivers and lakes	15	Low
21	*Puntius chola*	Worms, crustaceans, insects and plant matter	Shallow water of streams, rivers, canals, beels, haors, ponds	15	Aquarium
22	*Puntius sophore*	Phytoplanktons and algae	Rivers, streams and ponds	17	Aquarium
23	*Puntius ticto*	Crustaceans, insects and plankton	Still, shallow, marginal waters	10	Aquarium
24	*Systomus sarana*	Aquatic insects, shrimps, algae	Rivers, streams, lakes	40	Aquarium
25	*Cyprinus carpio*	Aquatic insects, crustaceans, annelids, mollusks, weed and tree seeds, wild rice, aquatic plants and algae	Slow flowing or standing water	120	Very high
26	*Sperata sarwari*	Small fish, crustaceans, insect larvae	Lakes and rivers	150	Very high
27	*Mystus bleekri*	Crustaceans, insect larvae	Lakes, tanks, rivers, canals	15	Low
28	*Mystus cavasius*	Crustaceans, insect larvae	Rivers and lakes; also beels, canals, ditches, ponds, and inundated	40	Low

			fields		
29	*Rita rita*	Insects, mollusks, shrimps and fishes	Rivers and estuaries	150	Very high
30	*Bagarius bagarius*	Insects, small fishes, frogs and shrimps	Rapid and rocky pools of large and medium-sized rivers	250	Very high
31	*Gagata cenia*	Insect larvae	Stagnant side pools of rivers	15	Low
32	*Ompok bimaculatus*	Fish crustaceans and mollusks	Shallow streams and rivers with moderate currents	45	Low
33	*Wallago attu*	Smaller fish, crustaceans, and mollusks	Rivers, lakes and tanks	240	Very high
34	*Heteropneustes fossilis*	Omnivorous	Ponds, ditches, swamps and marshes	30	Low
35	*Ailia coila*	Insects and shrimps	Large rivers and connected waters	30	Low
36	*Clupisoma garua*	Insects, shrimps, other crustaceans	Fresh water and tidal rivers	60	Very high
37	*Sicamugil cascasia*	Small insects and phytoplankton's	Rivers pools and shallow running waters	14	Low
38	*Xenentodon cancila*	Crustaceans, small fishes, insects	Rivers, ponds, canals	40	Low
39	*Channa marulia*	Fish, frogs, snakes, insects, earthworms and tadpoles	Deep pools of rivers and lakes	180	Very high
40	*Channa punctata*	Worms, insects and small fish	Ponds, swamps, brackish water ditches	30	Low
41	*Chanda nama*	Zooplanktons, insect larvae	Standing and running waters; clear streams, canals, ponds	10	Aquarium

42	*Parambasis baculis*	Zooplanktons, insect larvae	Standing and running waters; clear streams, canals, ponds	5	Aquarium
43	*Parambasis ranga*	Invertebrates worms and crustaceans	Sluggish and standing water	8	Aquarium
44	*Glossogobius giuris*	Small insects, crustaceans and small fish	Freshwater and estuaries	35	Aquarium
45	*Colisa fasciata*	Zooplanktons, insect larvae	Weedy environment of rivers, estuaries, ditches, ponds and lakes	12	Aquarium
46	*Oreochromis mossambicus*	Carnivorous/omnivorous, herbivorous or detritus feeders	Reservoirs, rivers, creeks, drains, ponds swamps and tidal creeks	39	High
47	*Mastacembelus armatus*	Benthic insect larvae, worms and some submerged plant material	Streams and rivers with sand, pebble	90	Aquarium

Among the 47 species recorded so far from the Chotiari Reservoir, 13 species viz., *Cirrhinus mrigala, Gibelion catla, Labeo calbasu, Labeo dyocheilus pakistanicus, Labeo gonius, Labeo rohita, Cyprinus carpio, Sperata sarwari, Rita rita, Bagarius bagarius, Wallago attu, Clupisoma garua, Eutropiichthys vacha* and *Oreochromis mossambicus* are highly commercially important. Among them *Cirrhinus reba, Cirrhinus mrigala, Gibelion catla Labeo calbasu, Labeo dyocheilus pakistanicus, Labeo gonius, Labeo rohita, Cyprinus carpio* are herbivorous while, *Sperata sarwari, Rita rita, Bagarius bagarius, Wallago attu, Clupisoma garua, and Eutropiichthys vacha* are carnivorous. Four species have fairly high economic importance. Nine species are important for Aquarium purpose. The rest 21 species, though, have less economic important but are an integral part of the ecological system and biodiversity.

The family Cyprinidae is the most specious family represented by 22 species while the other 25 species are divided among the fifteen families in various combinations. Majorities of the families are, however, represented by one or two species. The species *Securicula gora,* Rita *rita, Clupisoma garua, Glossogobius giuris* are rare species in Chotiari reservoir. Most of the species found in the reservoir are common (30 species), seven are less common and six are very common. The size ranges of the species show that maximum of the species range in size from 1-25 cm and only ten species have a maximum size of more than 100 cm. This again shows that this reservoir inhabits a reasonably good number of species of larger sizes. The reservoir has quite a good number of carnivorous species (Figure 2). It shows that there must be a high pressure on the small fish and most probably on the fish fries recruiting the reservoir. The carnivorous-herbivorous ratio needs a continuous monitoring so that the balance is not disturbed in future. During the present survey an increase in the population of Wallago attu (a fish eating species) was noticed to be enhanced though it was

being caught by a number of fishermen. During the time of survey 1000-1500 kg of this species was being caught daily as told by the fishermen.

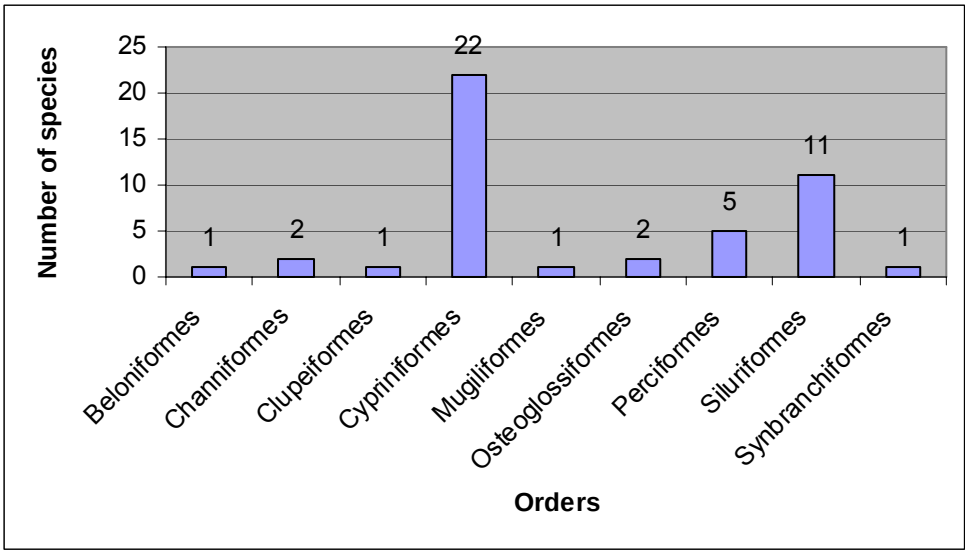
All the species of economic importance prefer the deep, clear waters. On the other hand, the species *Puntius sophore, Puntius ticto, Systomus sarana, Crossocheilus diplocheilus, Channa punctata, Colisa fasciata, Oreochromis mossambicus, Mastacembelus armatus* and *Heteropneustes fossilis* prefer the shallow waters with vegetation and muddy bed. The species, *Labeo gonius, Oreochromis mossambicus, Systomus sarana, Chanda nama, Parambasis baculis, Parambasis ranga,* prefer the low quality seepage but clear waters with sandy river beds. The species *Notopterus notopterus, Chela cachius, Salmophasia bacaila, Securicula gora, Amblypharyngodon mola, Esomus danricus, Ompok bimaculatus, Rasbora daniconius, Chanda nama, Parambasis baculis, Parambasis ranga,* and *Glossogobius giuris* prefer the shallow running waters with sandy river beds and are mostly found in inlet areas.

Presently eutrophication and absence of any recruiting facility is a major problem in the opinion of a common fisherman. Construction of reservoir has increased the water level in the reservoir. The more incoming water is also bringing large quantities fish seed from the river Indus. This has increased the fish catch to a reasonable extent. The record of fish landings is, however, not available which is a negative point for this otherwise healthy reservoir. The fisheries authority should manage the availability of a correct record of the fish catch so that healthy conditions for these important reservoirs could be maintained. If a minimum effort is put in for management of this reservoir, it can be an exemplary water body from fisheries point of view.

3.5.2 Distribution of orders and families

A total of 9 Orders were recorded over the 47 species with Cypriniformes (Carps) being the most dominant (22 species) followed by Siluriformes (Catfish) (12 species) and Perciformes (Perch) (5 species). The remaining orders were presented by one or two species only (**Figure 10**)

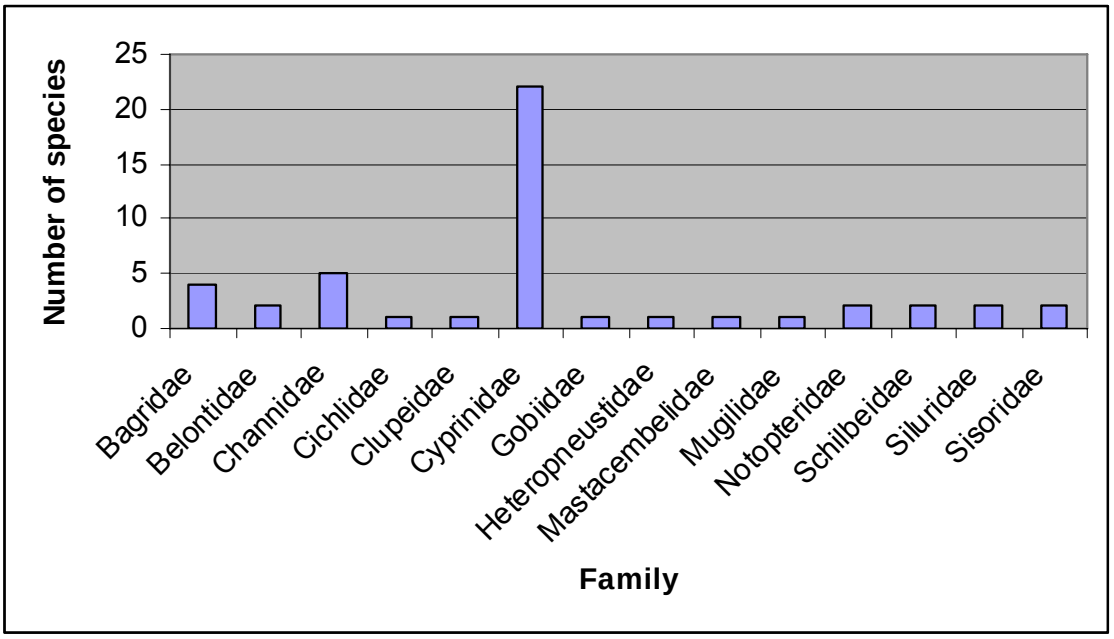
Figure 10 – Distribution of species across orders at Chotiari Reservoir



Out of the 14 families, Cyprinidae were by the most commonly represented (47%) followed by two other families having representation of more that two species i.e.

five species from Channidae and four species from Bagridae. **Figure 11** shows the graphical distribution of families respectively.

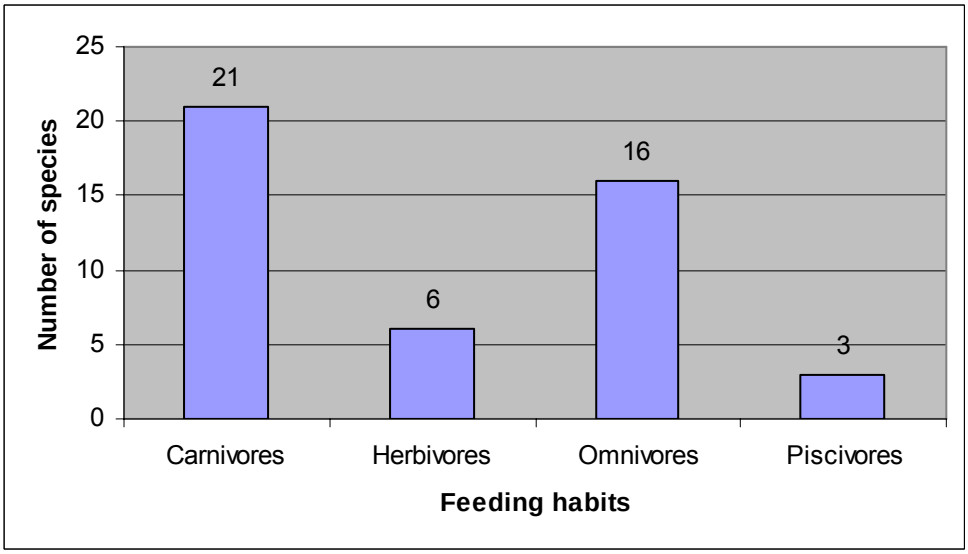
Figure 11 – Distribution of species across families at Chotiari Reservoir



3.5.3 Feeding habits

Out of the 47 species recorded the majority were carnivores (21) followed by omnivores (16). The remaining herbivores and Piscivores were represented by five and three species respectively. **Figure 12** gives the distribution of feeding habits.

Figure 12 – Food habits of different species in Chotiari Reservoir

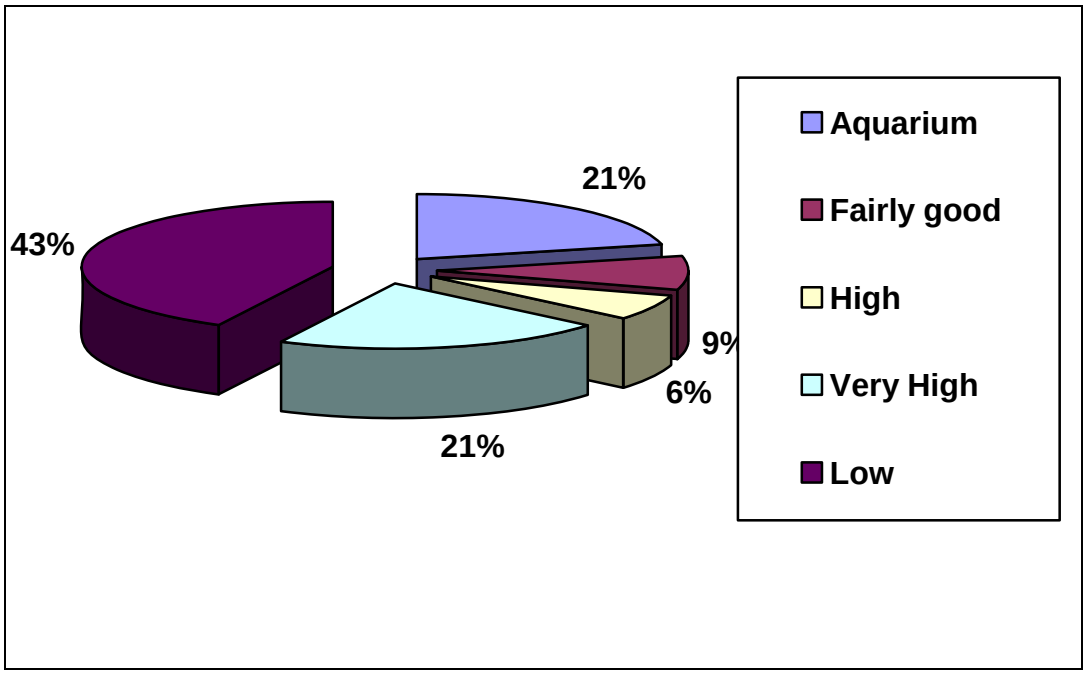


3.5.4 Commercial importance of fish recorded at Chotiari Reservoir

Most of the fish caught from Chotiari reservoir belonged to the economic value of Fairly Good (20 species, 48.5%) followed equally by Aquarium (10 species,

21.3%) and Very High (10 species, 21.3%). Fish species having High and Fairly Good economic attachment were represented by three to four species only. **Figure 13** shows the representation of economic vales over species.

Figure 13 – Commercial Importance of recorded species



3.5.5 Relative abundance

Relative abundance was calculated for each species and then divided into four categories namely Rare, Less Common, Common and Very Common. **Table 17** gives species wise relative abundance, relative status and country status.

Table 17 – Relative abundance and local and country status of different Fish species

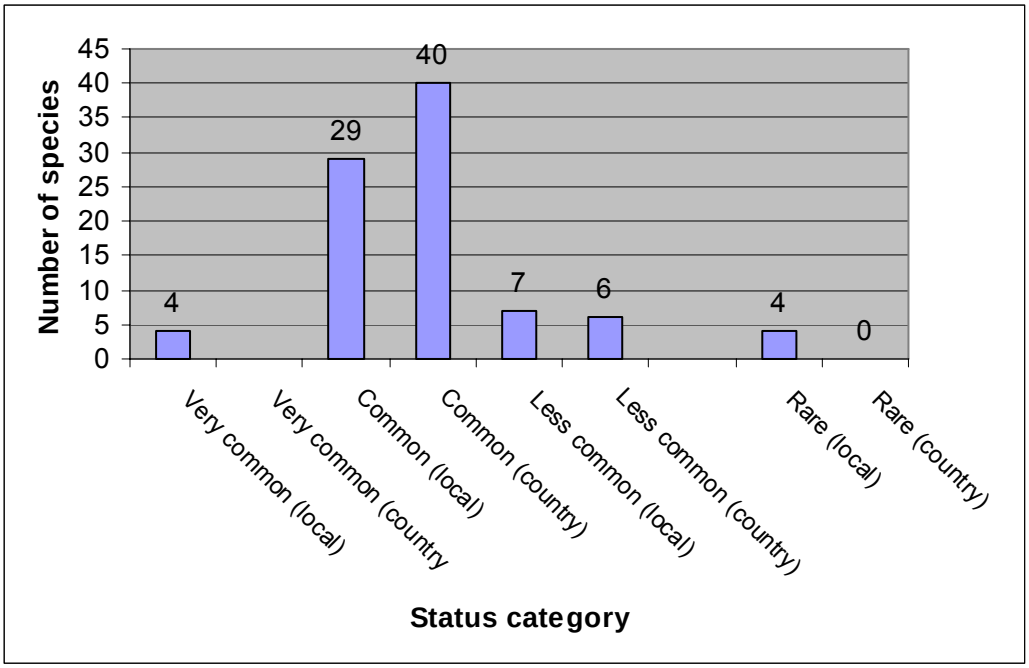
Nos.	Species	Catch per 100 efforts	Relative abundance	Status in Chotiari reservoir	Status in country
1	*Gudusia chapra*	5	0.62	Less common	Common
2	*Chitala chitala*	7	0.86	Less common	Less common
3	*Notopterus notopterus*	15	1.85	Common	Common
4	*Chela cachius*	10	1.23	Common	Common
5	*Salmophasia bacaila*	15	1.85	Common	Common
6	*Securicula gora*	4	0.49	Rare	Common
7	*Amblypharyngodon mola*	12	1.48	Common	Common
8	*Aspidoparia morar*	15	1.85	Common	Common
9	*Barilius vagra*	16	1.97	Common	Common
10	*Esomus danricus*	12	1.48	Common	Common

11	*Rasbora daniconius*	9	0.74	Less common	Less common
12	*Cirrhinus mrigala*	16	2.34	Common	Common
13	*Cirrhinus reba*	22	2.71	Common	Common
14	*Gibelion catla*	5	0.62	Less common	Common
15	*Labeo calbasu*	16	1.97	Common	Common
16	*Labeo dero*	12	1.48	Common	Common
17	*Labeo dyocheilus pakistanicus*	6	0.74	Less common	Less Common
18	*Labeo gonius*	18	2.22	Common	Common
19	*Labeo rohita*	10	1.23	Common	Common
20	*Osteobrama cotio*	25	3.08	Common	Common
21	*Puntius chola*	6	0.74	Less common	Less Common
22	*Puntius sophore*	42	5.17	Very Common	Common
23	*Puntius ticto*	38	4.68	Very Common	Common
24	*Systomus sarana*	11	1.35	Common	Less Common
25	*Cyprinus carpio*	16	1.97	Common	Common
26	*Sperata sarwari*	8	0.99	Common	Less common
27	*Mystus bleekri*	28	3.45	Common	Common
28	*Mystus cavasius*	36	4.43	Very Common	Common
29	*Rita rita*	2	0.25	Rare	Less common
30	*Bagarius bagarius*	24	2.96	Common	Common
31	*Gagata cenia*	20	2.46	Common	Common
32	*Ompok bimaculatus*	36	4.43	Very Common	Common
33	*Wallago attu*	25	3.08	Common	Common
34	*Heteropneustes fossilis*	15	1.85	Common	Common
35	*Ailia coila*	25	3.08	Common	Common
36	*Clupisoma garua*	3	0.37	Rare	Common
37	*Sicamugil cascasia*	7	0.86	Less common	Common
38	*Xenentodon cancila*	18	2.22	Common	Common
39	*Channa marulia*	11	1.35	Common	Common
40	*Channa punctata*	20	2.46	Common	Common
41	*Chanda nama*	28	3.45	Common	Common
42	*Parambasis baculis*	36	4.43	Very Common	Common
43	*Parambasis ranga*	30	3.69	Common	Common
44	*Glossogobius giuris*	4	0.49	Rare	Common
45	*Colisa fasciata* Bloch and Schneider	15	1.85	Common	Common
46	*Oreochromis mossambicus*	40	4.93	Very common	Common
47	*Mastacembelus armatus*	18	2.22	Common	Common
TOTAL SPECIMENS		**812**			
Rare = 0.00-0.5, Less Common=0.51-1.00, Common = 1.10-3.99, Very common = > 4.00					

At both site level (relevant) and country levels status most of the species were common. However there was some difference between the two levels for the common category. There were no very common or rare species for country levels. **Figure 14** gives a graphical representation of local and national status of

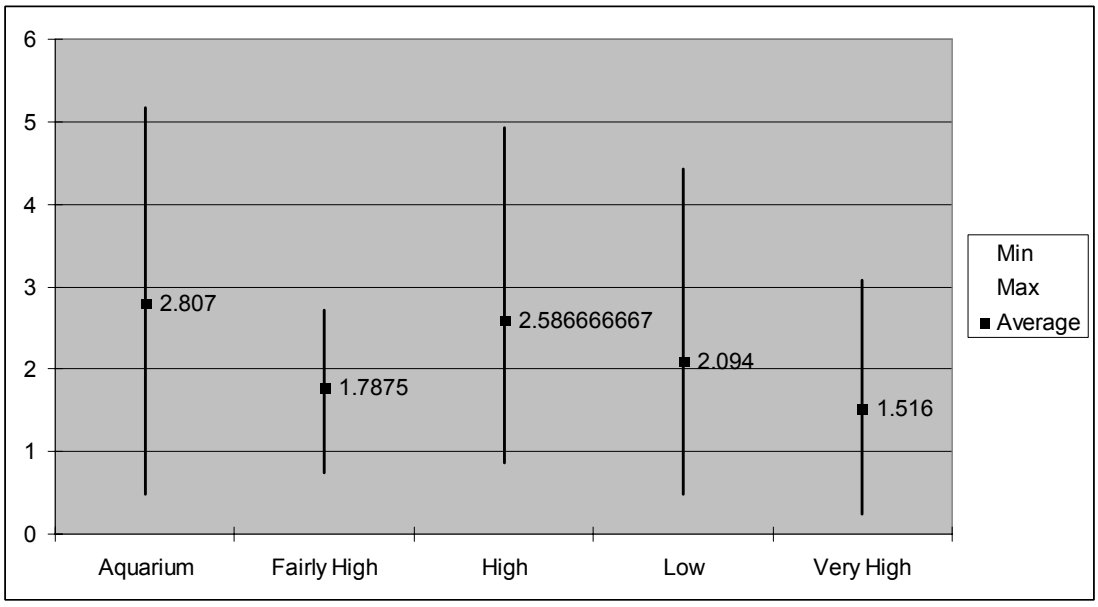
fish species recorded from Chotiari Reservoir

Figure 14 – Status of fish species in Chotiari reservoir and Pakistan



Looking at the relative densities against economic values, there was some variation in averages. Species with aquarium related values had the highest average values (2.807) followed by species of low economic value. Species with Fairly High and Very High economic values were relatively less abundant. **Figure 15** shows the minimum, maximum and average relative density vales for each economic category.

Figure 15 – Minimum, maximum and average relative density vales for each economic category.



3.5.6 Threats and recommendation

3.5.6.1 Threats

Chotiari reservoir is an area which has the least problems regarding pollution, over fishing, introduction of exotic species, etc. It, however, has other problems that are not met in other lakes of the coastal areas. Some of these problems are:

- **Unsustainable fishing practices:** The use of unsustainable fishing practices by the fishing contractors is undermining long-term sustainability of fisheries in these lakes. These include, use of small size fishing nets, use of poison and chemicals and over fishing. Degradation of fisheries Preliminary Environmental Baseline Study of the Indus for All Programme Sites poses a potential threat to the livelihood of local fishing communities. The shortage of freshwater is also affecting the hydrological regimes of different lakes in the area.

- **Eutrophication of Reservoir:** Chotiari reservoir falls in tropical areas with very hot summers. The water temperature reaches to 33º C during the summer months. The lakes are full of vegetation. As dead and dry part of this vegetation decays during the hot summer months and releases extra nutrients in the lake which in turn cause the growth of more and more vegetation and algal blooms. Both these phenomena cause eutrophication on one hand and cause a sudden deficiency in the dissolved oxygen, which can be fatal for many fish species. This situation is more dangerous during night when there is no photosynthetic activity and the dissolved oxygen is taken up by the decaying organic matter and the phytoplankton.

- **Lack of hatching Facility on the reservoir:** All the lakes in the Chotiari reservoir area are regularly auctioned. During flood year's substantial fish these lakes from the river through floodwater receive seed but when there are no floods for many consecutive years, the fish stocks in the lakes get depleted. For sustainable fisheries exploitation, a network of hatcheries must be established on different points of the reservoir so that the fishes of commercial importance continuously recruit the lakes. This will result in an increase in the income of fishermen on one hand and in the Govt. exchequer on the other as the lakes will be auctioned at a higher rate.

- **Lack of data from fish landings spots:** At the moment record regarding fish landings is not available. The contractor probably intends to hide the records about the quantity of fish caught from the reservoir. It is very important to get the data regarding fish landings so that future planning for sustainable fisheries in the area could be managed.

- **Exploitation of Fishermen by the Contractor:** The Chotiari reservoir is far away from the big cities like Karachi and Hyderabad and in the vicinity there is not even a small city or town. All the fish caught by the fishermen has to be sold to the local contractor. The contractor purchases the fish from the local fishermen at extremely low rates. The prized fish like Rohu, Mori and Theila are purchased at a rate of Rs. 40/kg whereas this fish is sold in Lahore, Karachi and Hyderabad at a rate of Rs. 200-300/kg.

3.5.62 Recommendations

- There should be gradually clearing of the lakes from weeds and aquatic plants using dredges and other mechanical gadgets;
- A network of hatcheries be established at the reservoir to recruit the lakes for improving fish stocks in the lakes for sustainable use of the fisheries resources;
- Installation of cold storage facilities should be introduced for storing fish for few days;
- Involve the private sector for the establishment of cold storages and sale points so that local people could sell their catch at an appropriate rate;
- The monopoly of the local influential contractors should be controlled through open auctions of the water bodies for fishing rights;
- The local fishermen may be granted loans at low interest so that they could purchase the boats and fishing equipment;
- The local fishermen organization may be strengthened so that they could protect their rights;
- A sound procedure for recording data about fish landings is a necessary for future fisheries management in the reservoir.

3.6 Phytoplankton

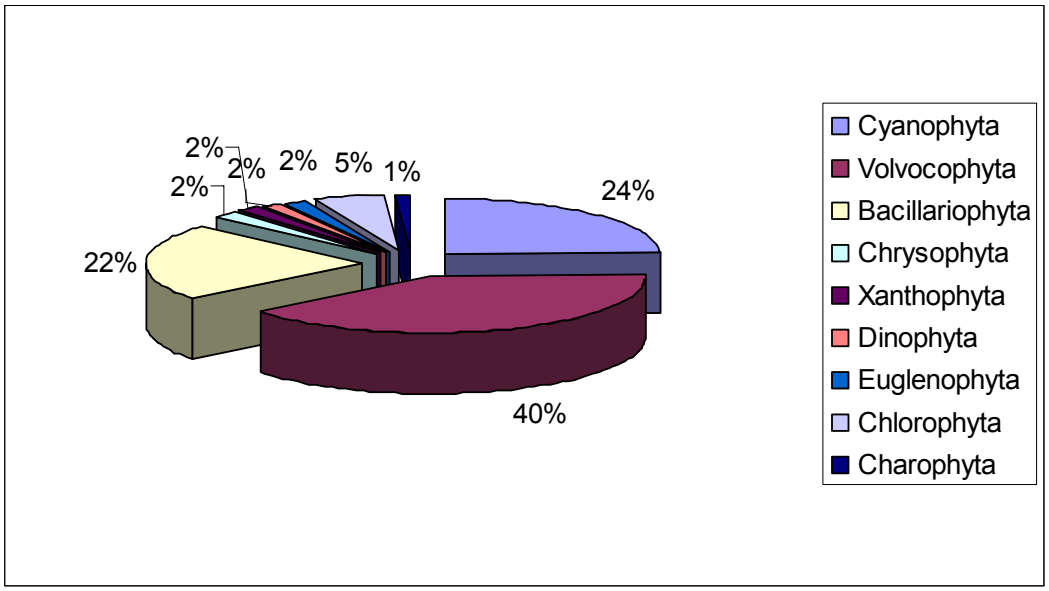
3.6.1 Summer Flora

Table 18 shows the number of classes, orders families, genera and species found in each phylum from Chotiari Reservoir in summer. The phylum Volvocophyta had the most representation with 100 species being obtained. Figure

Table 18 – Distribution of Phytoplankton/Algal species in Chotiari Reservoir

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	3	3	20	60
PROTISTA	Volvocophyta	2	5	11	35	100
	Bacillariophyta	1	2	8	20	55
	Chrysophyta	1	1	1	4	5
	Xanthophyta	1	1	1	4	4
	Dinophyta	1	1	2	2	4
	Euglenophyta	1	1	1	2	3
PROTOCTISTA	Chlorophyta	3	4	5	6	13
	Charophyta	1	1	1	2	3
Total: 3	9	15	19	33	96	248

Figure 16 – Percentage of species against phylum recorded in Chotiari reservoir (summer)



3.6.2 Discussion (summer)

- **Blue green algae:** A total of 248 species of nine phyla in which 60 species (24.2%) belonging to 20 genera of phyla Cyanophyta were observed. A total number of 13 species belong to the genus *Chroococcus;* 7 species of the genus *Gloeocapsa,* 5 species of each genus *Gomphosphaerica* and *Oscillatoria,* 4 species of each genus *Aphanothece* and *Lyngbya,* 3 species of each genus *Merismopedia* and *Anabaena,* 2 species each of the genera *Aphanocapsa, Microcystis, Phormidium, Spirulina,* one species of each genera *Coelosphaerium, Cyanarcus, Eucapsis, Pseudoholopedia, Rhabdoderma, Synechococcus, Synechocystis* were recorded. The species of *Chroococcus, Gloeocapsa, Lyngbya* have thick sheath. They indicate saline and brackish water; species of *Spirulina* and *Oscillatoria* are included in medicinal group and are used to prepare vitamins. In technologically advanced countries they have a high market value. Species of the genus *Anabaena* are included in nitrogen fixing group. They have a capacity to fix nitrogen in heterocystis which is beneficial for crops like maize, rice, sugarcane; species of *Aphanocapsa, Aphanothece, Coelosphaericum, Gloeothece, Microcystis* are included in toxic group. They create their toxicity in water as blooms and cause death within 24 hours. The initial symptoms are thirst, fever, diarrhea, pain, muscle pain, headache, vomiting, etc. Species of the genus *Gomphosphoeria, Merismopedia, Microcystis, Pseudoholopedia, Oscillatoria, Spirulina,* are included in planktonic group as Eu, Phyto, Tycho, and Nano-plankton. Species of the genus *Rhabdoderma, Synechococcus, Synechocystis* are included in epiphytic group. Generally blue green algal species are good indicator for high ratio of total hardness. They resist the temperature in layer form and found. Fossil recorded from Precambrian of geological time scale. The good habitat of *Spirulina* is high salinity along with high water temperature according to experts/scientists. Summer and monsoon season are the best season for blue green algal species.
- **Green algal species:** 100 species (40.3%) belonging to 35 genera of Volvocophyta were found. The high ratio/maximum species were recorded

from all other groups. They produce dissolved oxygen which is beneficial for aquatic life, fauna and fish. This is the main reason to find number of species of fishes. This reservoir is a great source of water for millions of people e.g. irrigation, drinking, fishing etc. From this group the highest number of 15 species of the genus *Cosmarium* were found, 10 species of the genus *Oocystis,* 8 species of genus *Tetraedron*, 7 species of genus *Scenedesmus,* 5 species of genus *Staurastrum,* 4 species of each genus *Trochiscia, Crucigena, Chlamydomonas,* 3 species of the each genus *Ankistrodesmus, Coelastrum, Dictyosphaerium, Euastrum,* 2 species of the each genus *Pediastrum, Chlorella, Gloeocystis, Penium,* one species of each genus *Chodatella, Closteriopsis, Excentrosphaeria, Gloeotaenium, Kirchneriella, Nephrocytium, Planktosphaeria, Westella, Characium, Palmella, Eudorina, Pandorina, Pleodorina, Volvox, Arthrodesmus, Cosmocladium, Pleurotaenium, Micrasterias* were founded. The species *Micrasterias, Euastrum, Pleurotaenium, Penium, Staurastrum, Cosmocladium, Cosmarium, Closterium, Arthrodesmus* are included in hypolimnion flora. They are good indicator of calcium hardness in water body. Species of *Characium* are good indicator of neutral/soft water species of *Eudorina, Pandorina, Pleodorina, Volvox, Chlamydomoras, Gloeocystis, Chlorella, Scenedesmus, Crucigenia* are included in medicinal group. Species *Pediastrum* are good indicator for the high ratio of chlorides. All the green algal species are top most/best quality and delicious food for fauna, fishes etc.

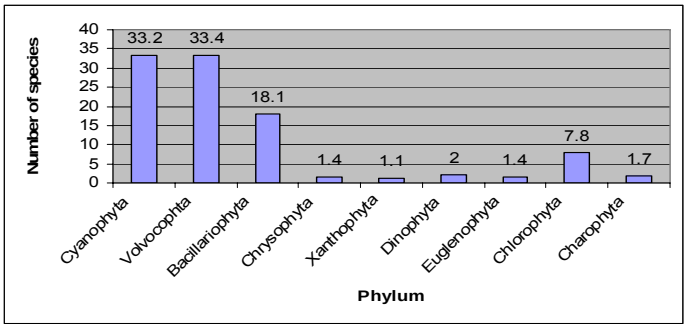
3.6.3 Winter

Table 19 shows the distribution of phytoplankton and algal species recorded from Chotiari Reservoir during the winter survey. **Figure 17** gives a graphical display.

Table 19 – Distribution of phytoplankton/algal species in Chotiari Reservoir during November, 2007 winter flora

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	3	6	28	119
PROTISTA	Volvocophyta	2	5	11	36	120
	Bacillariophyta	1	2	8	22	65
	Chrysophyta	1	1	2	4	5
	Xanthophyta	1	1	1	4	4
	Dinophyta	1	1	2	3	7
	Euglenophyta	1	1	1	3	5
PROTOCTISTA	Chlorophyta	3	4	8	14	28
	Charophyta	1	1	1	2	6
Total: 3	9	15	19	40	116	359

Figure 17 – Percentage of species against phylum recorded in Chotiari reservoir (winter)



3.6.4 Discussions (winter)

During field work in November 2007 more than 100 samples were collected from Chotiari reservoir dam, out of these a total of 359 algal species belonging to 116 genera of 9 phyla namely Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta along with 80 aquatic plants and 32 fishes were recorded.

- **Blue green algae:** 119 species belonging to 28 genera of the phyla Cyanophyta in which maximum 15 species of the genus *Chroococcus,* 12 species of the genus *Oscillatoria* and 10 species of the each genus *Gloeocapsa* and *Lyngbya,* 6 species of the genus *Aphanocapsa* and *Spirulina,* 5 species of the each genus *Aphanothece, Gomphospheria, Merismopedia, Phormidium,* 4 species of the each genus *Microcystis, Anabaena, Nostoc, Gloeotrichia,* 3 species of the each genus *Synechococcus, Cylindrospermum, Tolypothrix, Calothrix,* 2 species of the each genus *Coelosphaerium, Aulosira,* and one species of the each genus *Cyanarcus, Eucapsis, Gloeothece, Pseudoholopedia, Rhabdoderma, Synechocystis, Arthrospira, Nodularia,* were represented.

- **Green algae:** 120 species belonging to 36 genera of the phyla Volvocophyta in which maximum species of the genus *Cosmarium* was recorded. It was followed by 10 species of the genus *Oocystis,* 9 species of the genus *Scenedesmus,* 8 species of the each genus *Tetraedron, Closterium, Euastrum,* 7 species of the genus *Pediastrum,* 5 species of the each genus *Trochiscia, Staurastrum,* 4 species of the each genus *Ankistrodesmus, Crucigenia, Chlamydomonas,* 3 species of the each genus *Coelastrum, Dictyospherium,* 2 species of the each genus *Closteriopsis, Characium, Chlorella, Gloeocystis, Penium,* one species of the each genus *Chodatella, Excentrosphaeria, Gloeotaenium, Kirchneriella, Nephrocytium, Pleodorina, Volvox, Arthrodesmus, Cosmocladium, Desmidium, Pleurotaenium, Micrasterias* were represented.

- **Golden brown algae:** 65 species belonging to 22 genera of the phyla Bacillariophyta in which maximum 9 species of the genus *Navicula,* 6 species of the each genus *Cymbella, Synedra,* 5 species of the genus *Amphora,* 4 species of the genus *Achnanthes, Cyclotella,* 3 species of the each genus *Gomphonema, Gyrosigma, Pinnularia, Epithemia, Nitzchia,* 2 species of the each genus *Cocconies, Dentiacla, Diatoma, Melosira, Surirella,* one species of the each genus *Frustulia, Neidium, Rhopaldia, Eunolia* were represented.

- **Chrysophyta:** 5 species belonging to 4 genera of the phyla Chrysophyta, in which maximum 2 species of the genus *Dinobryon* and one species of the each genus *Chrysocapsa, Mallomonas, Spiniferomonas* were represented.

- **Xanthophyta:** 4 species belonging to 4 genera of the phyla Xanthophyta one species of each genus *Botryococcus, Cchlorellidiopsis, Goniochloris, Ophiocytium* were represented.

- **Dinophyta:** 7 species belonging to 3 genera of the phyla Dinophyta in which 4 species of the genus *Peridinium,* 2 species of the genus *Glenodinium* and one species of the genus *Ceratium* were represented.

- **Flagellales group:** 5 species belonging to 3 genera of the phyla Euglenophyta, 3 species of the genus *Euglena* and one species of the each genus *Phacus, Trochelomonas* were represented.

- **Grass green algae:** 28 species belonging to 14 genera of the phyla Chlorophyta in which 7 species of the each genus *Spirogyra* 4 species of the genus *Mougeotia,* 2 species of the each genus *Ulothrix, Microspora, Oedogonium, Zygnema, Chaetophora,* one species of the each genus *Geminella, Cylindrocapsa, Basicladia, Cladophora, Aphanochaete, Coleochaete* were represented.

- **Charophyta:** 6 species belonging to 2 genera of the phyla Charophyta. Five species of the genus *Chara,* and one species of the genus *Nitella* were represented.

3.6.5 Summer and winter

Table 20 shows the number of species (and their percentage) for summer and winter from Chotiari Reservoir.

Table 20 – Data of aquatic invertebrates collected from Chotiari Reservoir during the summer and winter surveys

	Name of Genera	Number of species winter	%	Number of species summer	%
	Kingdom: MONERA				
	Phylum: Cyanophyta				
	Class: Chroocophyceae				
	Order: Chroococcales				
	Family: Chroococcaceae				
1.	*Aphanocapsa*	6	1.7	2	0.81
2.	*Aphanothece*	5	1.4	4	1.61
3.	*Chroococcus*	15	4.2	13	5.24
4.	*Coelosphaerium*	2	0.6	1	0.4
5.	*Cyanarcus*	1	0.3	1	0.4
6.	*Eucapsis*	1	0.3	1	0.4
7.	*Gloeocapsa*	10	2.8	7	2.82
8.	*Gloeothece*	1	0.3	1	0.4
9.	*Gomphosphaeria*	5	1.4	5	2.02
10.	*Merismopedia*	5	1.4	3	1.2
11.	*Microcystis*	4	1.1	2	0.81
12.	*Pseudoholopedia*	1	0.3	1	0.4
13.	*Rhabdoderma*	1	0.3	1	0.4
14.	*Synechococcus*	3	0.8	1	0.4
15.	*Synechocystis*	1	0.3	1	0.4
	Class: Nostocophyceae				
	Order: Oscillatoriales				
	Family: Oscillatoriaceae				
16.	*Arthrospira*	1	0.3	0	0
17.	*Lyngbya*	10	2.8	4	1.61
18.	*Oscillatoriea*	12	3.3	5	2.02
19.	*Phormidium*	5	1.4	2	0.81
20.	*Spirulina*	6	1.7	2	0.81
	Order: Nostocales				
	Family: Nostocaceae				
21.	*Anabaena*	4	1.1	3	1.2
22.	*Aulosira*	2	0.6	0	0
23.	*Cylindrospermum*	3	0.8	0	0
24.	*Nostoc*	4	1.1	0	0
	Family: Scytonemataceae				

25.	*Nodularia*	1	0.3	0	0
26.	*Tolypthrix*	3	0.8	0	0
	Family: Rivulariaceae				
27.	*Calothrix*	3	0.8	0	0
28.	*Gloeotrichia*	4	1.1	0	0
	Kingdom: PROTISTA				
	Phylum: Volvocophyta				
	Class: Volvocophyceae				
	Order: Chlorococcales				
	Family: Oocystaceae				
1.	*Ankistrodesmus*	4	1.1	3	1.2
2.	*Chodatella*	1	0.3	1	0.4
3.	*Closteriopsis*	2	0.6	1	0.4
4.	*Excentrosphaera*	1	0.3	1	0.4
5.	*Gloeotaenium*	1	0.3	1	0.4
6.	*Kirchneriella*	1	0.3	1	0.4
7.	*Nephrocytium*	1	0.3	1	0.4
8.	*Oocystis*	10	2.8	10	4
9.	*Planktosphaeria*	1	0.3	1	0.4
10.	*Tetraedron*	8	2.2	8	3.2
11.	*Trochiscia*	5	1.4	4	1.61
12.	*Westella*	1	0.3	1	0.4
	Family: Characiaceae				
13.	*Characium*	2	0.6	1	0.4
	Family: Coelastraceae				
14.	*Coelastrum*	3	0.8	3	1.2
	Family: Dictyosphaeriaceae				
15.	*Dictyospherium*	3	0.8	3	1.2
	Family: Hydrodictyaceae				
16.	*Pediastrum*	7	2	2	0.81
	Family Scenedesmaceae				
17.	*Crucigenia*	4	1.1	4	1.61
18.	*Scenedesmus*	9	2.5	7	2.82
	Order: Chlorellales				
	Family: Chlorellaceae				
19.	*Chlorella*	2	0.6	2	0.81
	Order Tetrasporales				
	Family: Palmellaceae				
20.	*Gloeocystis*	2	0.6	2	0.81
21.	*Palmella*	1	0.3	1	0.4
	Order: Volvocales				
	Family: Chlamydomonadaceae				
22.	*Chlamydomonas*	4	1.1	4	1.61
	Family: Volvocaceae				
23.	*Eudorina*	1	0.3	1	0.4
24.	*Pandorina*	1	0.3	1	0.4
25.	*Pleodorina*	1	0.3	1	0.4
26.	*Volvox*	1	0.3	1	0.4
	Class: Desmidiophyceae				
	Order: Desmidiales				
	Family: Desmidiaceae				
27.	*Arthrodesmus*	1	0.3	1	0.4
28.	*Closterium*	8	2.2	4	1.61
29.	*Cosmarium*	15	4.2	15	6.1
30.	*Cosmocladium*	1	0.3	1	0.4
31.	*Desmidium*	1	0.3	0	0
32.	*Euastrum*	8	2.2	0	0
33.	*Staurastrum*	5	1.4	5	2
34.	*Penium*	2	0.6	2	0.81
35.	*Pleurotaenium*	1	0.3	1	0.40.4
36.	*Micrasterias*	1	0.3	0	0
	Phylum: Bacillariophyta				

	Class: Bacillariophyceae				
	Order: Centrales				
	Family: Coscinodiscaceae				
1.	*Cyclotella*	4	1.1	3	1.2
2.	*Melosira*	2	0.6	2	0.81
	Order: Biddulphiales				
	Family: Achnanthaceae				
3.	*Achnanthes*	4	1.1	4	1.61
	Family: Cymbellaceae				
4.	*Amphora*	5	1.4	4	1.61
5.	*Cymbella*	6	1.7	6	2.4
	Family: Gomphonemaceae				
6.	*Gomphonema*	3	0.8	2	0.81
	Family: Naviculaceae				
7.	*Cocconies*	2	0.6	0	0
8.	*Gyrosigma*	3	0.8	2	0.81
9.	*Frustulia*	1	0.3	1	0.4
10.	*Navicula*	9	2.5	8	3.2
11.	*Neidium*	1	0.3	1	0.4
12.	*Pinnularia*	3	0.8	3	1.2
13.	*Rhopaldia*	1	0.3	1	0.4
	Family: Epithemiaceae				
14.	*Denticula*	2	0.6	2	0.81
15.	*Epithemia*	3	0.8	3	1.2
	Family: Fragilariaceae				
16.	*Fragilaria*	1	0.3	1	0.4
17.	*Diatoma*	2	0.6	2	0.81
18.	*Synedra*	6	1.7	6	2.4
19.	*Tabellaria*	1	0.3	1	0.4
	Family: Nitzschiaceae				
20.	*Nitzschia*	3	0.8	2	0.81
	Family: Eunotiaceae				
21.	*Eunotia*	1	0.3	1	0.4
	Family: Surirelliaceae				
22.	*Surirella*	2	0.6	0	0
	Phylum: Chrysophyta				
	Class: Chrysophyceae				
	Order: Ochromonadales				
	Family: Chrysocapsaceae				
1.	*Chrysocapsa*	1	0.3	1	0.4
	Family: Dinobryaceae				
2.	*Dinobryon*	2	0.6	2	0.81
3.	*Mallomonas*	1	0.3	1	0.4
4.	*Spiniferomonas*	1	0.3	1	0.4
	Phylum: Xanthophyta				
	Class: Xanthophyceae				
	Order: Mischococcales				
	Family: Chlorobotrydaceae				
1.	*Botryococcus*	1	0.3	1	0.4
2.	*Chlorellidiopsis*	1	0.3	1	0.4
3.	*Goniochloris*	1	0.3	1	0.4
4.	*Ophiocytium*	1	0.3	1	0.4
	Phylum: Dinophyta				
	Class: Dinophyceae				
	Order: Peridiniales				
	Family: Ceratiaceae				
1.	*Ceratium*	1	0.3	1	0.4
	Family: Peridiniaceae				
2.	*Glenodinium*	2	0.6		
3.	*Peridinium*	4	1.1	3	1.2

	Phylum: Euglenophyta				
	Class: Euglenophyceae				
	Order: Euglenales				
	Family: Euglenaceae				
1.	*Euglena*	3	0.8	2	0.81
2.	*Phacus*	1	0.3	1	0.4
3.	*Trachelomonas*	1	0.3	1	0.4
	Kingdom: PROTOCTISTA				
	Phylum: Chlorophyta				
	Class: Ulvophyceae				
	Order: Ulotrichales				
	Family: Ulotrichaceae				
1.	*Geminella*	1	0.3	1	0.4
2.	*Ulothrix*	2	0.6	2	0.81
3.	*Uronema*	1	0.3	0	0
	Family: Cylindrocapsaceae				
4.	*Cylindrocapsa*	1	0.3	0	0
	Family: Microsporaceae				
5.	*Microspora*	2	0.6	2	0.81
	Class: Siphonocladophyceae				
	Order: Cladophorales				
	Family: Cladophoraceae				
6.	*Basicladia*	1	0.3	0	0
7.	*Cladophora*	1	0.3	1	0.4
	Class: Zygnemophyceae				
	Order: Oedogoniales				
	Family: Oedogoniaceae				
8.	*Oedogonium*	2	0.6	2	0.81
	Order: Zygnemales				
	Family: Zygnemaceae				
9.	*Mougeotia*	4	1.1		
10.	*Spirogyra*	7	2	5	2
11.	*Zygnema*	2	0.6	0	0
	Order: Chaetophorales				
	Family: Chaetophoraceae				
12.	*Chaetophora*	2	0.6	0	0
	Family: Coleochaetaceae				
13.	*Aphanochaete*	1	0.3	0	0
14.	*Coleochaete*	1	0.3	0	0
	Phylum: Charophyta				
	Class: Charophyceae				
	Order: Charales				
	Family: Characeae				
1.	*Chara*	5	1.4	2	0.81
2.	*Nitella*	1	0.3	1	0.4

Figure 18 – Number of species found in each phylum during summer and winter

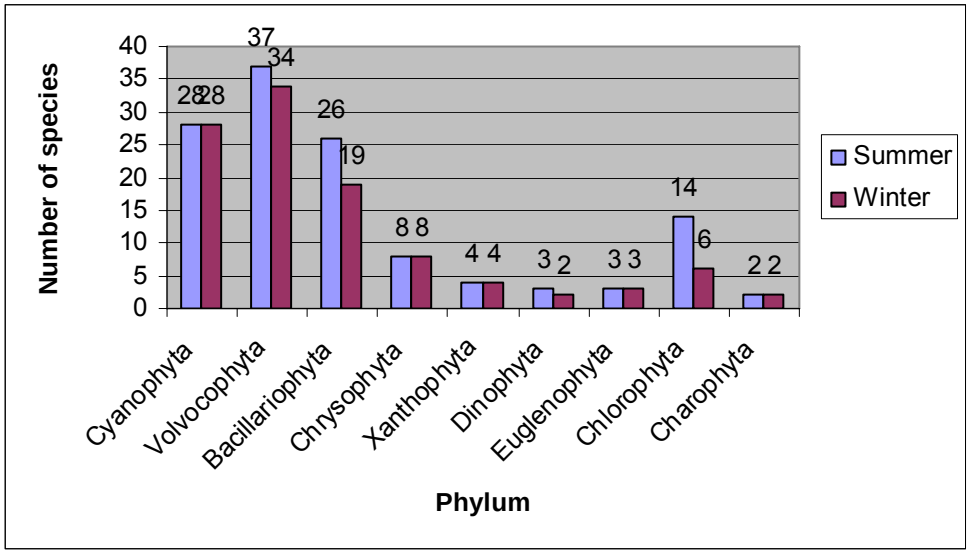


Figure 18 gives a graphical display of the number of species recorded over phylum from Chotiari Reservoir over summer and winter

A total of 85 algal/phytoplankton samples were collected during the summer months out of which 248 algal species belonging to 96 genera of 9 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta and during the second survey in November 2007 more than 100 samples were collected from Chotiari reservoir dam, out of these a total of 359 algal species belonging to 116 genera of 9 phyla Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta, 80 aquatic plants and 32 fishes along with some physico-chemical parameters were recorded.

3.6.6 Threats and recommendations

No threats or recommendations were made for Chotiari Reservoir by the consultant. However the following observations were made:

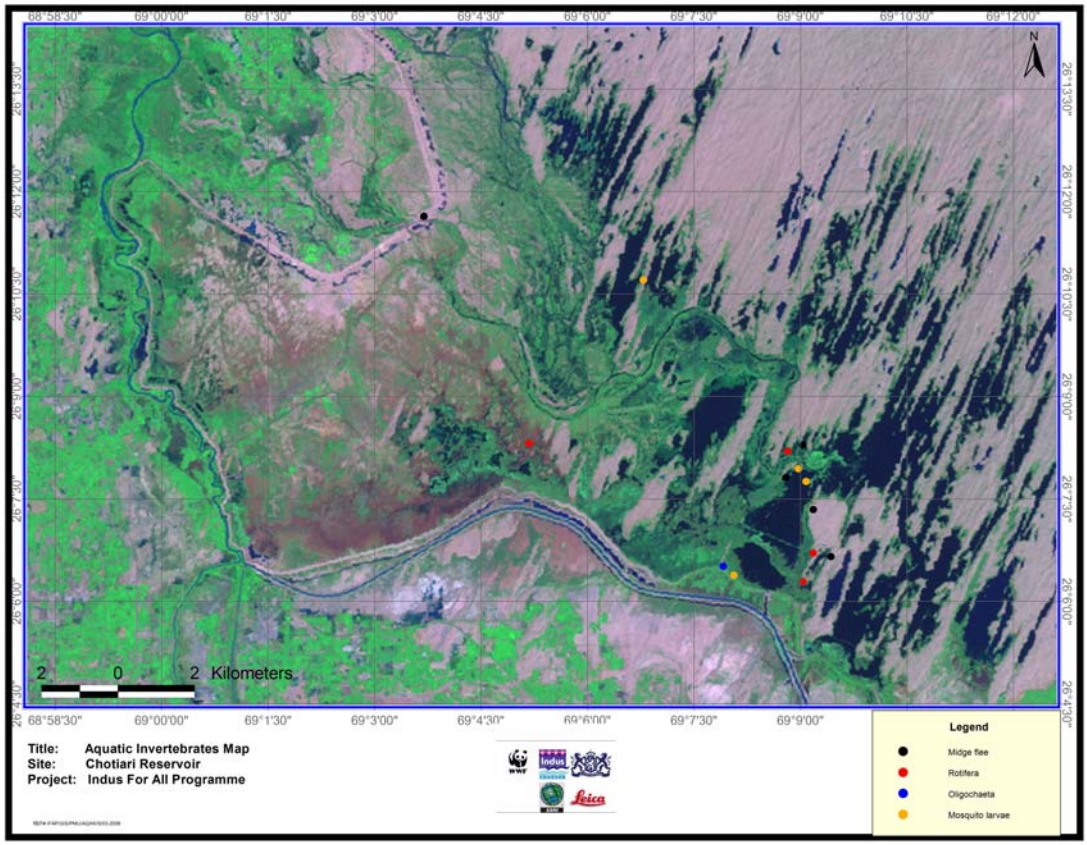
- Chotiari Reservoir is highly productive in all respect and is eutrophic and the water was found to be alkaline throughout the lake;
- Detail study needed for long time and latest equipments;
- Flow, turbidity, rain, flood, all these factors are affecting on the growth of the algal/phytoplankton vegetation;
- Thick algal/phytoplankton vegetation were accompanied by an increase in dissolved oxygen and pH.

3.7 Zooplankton

3.7.1 Sample details

Map 8 shows the sample points for zooplankton survey at Chotiari Reservoir. Details of the sampling points can be found in the annexure document

Map 8 – Showing the sample points for aquatic zooplankton survey at Chotiari Reservoir



3.7.2 Summary

During the summer survey of 2007 the Reservoir and its adjoining areas were explored for the micro-invertebrate sampling at various sampling sites. Some of the same as well as many more sites were visited during winter 2007 and adequate sampling was conducted. Observations were recorded regarding the terrestrial and aquatic invertebrate fauna of the Reservoir and its adjoining areas. **Tables 21** and **22** give the details of terrestrial and aquatic invertebrates collected from Chotiari Reservoir during summer and winter summer.

Map 9 – Showing the sample points for terrestrial zooplankton survey at Chotiari Reservoir

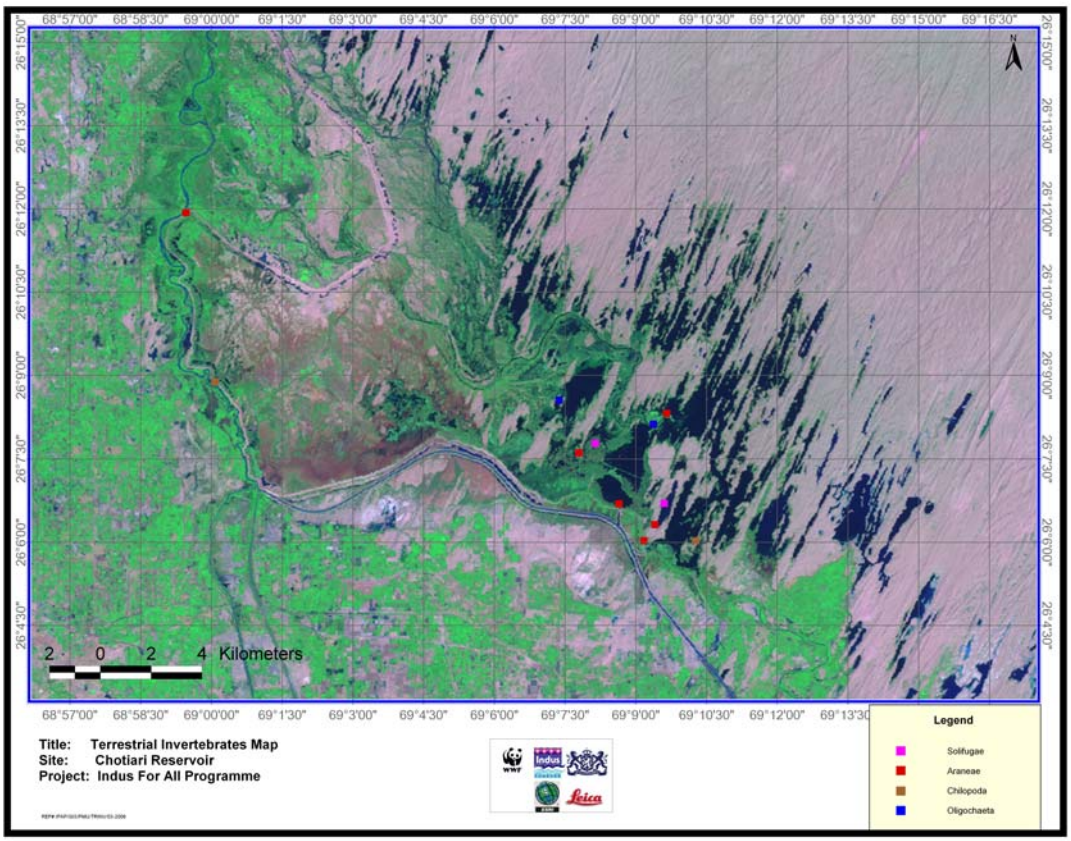


Table 21 – Data of terrestrial invertebrates collected from Chotiari Reservoir

S. No.	Invertebrate groups Terrestrial	Locality (Coordinates)	Date
1	Araneae	Saddori Bit: N 24º 52′ 161″, E 68º 02′ 695″ Makhdoom of Haala: N 24º 52′ 159″, E 68º 02′ 687″ Bakar Pathan: N 26º 05′ 458″, E 69º 09′ 171″ Bakar/ RD-165: N 26º 05′ 799″, E 69º 09′ 403″ Bakar Outlet: N 26º 06′ 245″, E 69º 08′ 644″ N 24º 52′ 154″, E 68º 02′ 645	17-6-07 19-6-07 14-10-07 15-10-07 16-10-07 16-10-07
2	Solifugae	Bakar/ RD-165: N 26º 05′ 799″, E 69º 09′ 403″ Saddori Bit: N 24º 52′ 160, E 68º 02′ 693	18-6-07 15-10-07
3	Chilopoda	Goth Maula Bakhsh Behan: N 26º 08′ 820″, E 69º 00′ 082″ Bakar Leh: N 24º 52′ 161″, E 68º 02′ 675″	17-6-07 16-10-07
4	Oligochaeta.	N 26 08’ 199’’, E 069 08’ 959’’ Saddori Bit: N 24º 52′ 143″, E 68º 02′ 687″	17-6-07 19-10-07

Table 22 – Data of aquatic invertebrates collected from Chotiari Reservoir

S. No.	Invertebrate groups: Aquatic	Locality (Coordinates)	Date
1	*Rotifera*	N 26 06' 288'', E 69 09' 181'' N 26 06' 706'' , E069 09' 334'' N 26 08' 313'', E 069 05' 172'' N 26 08' 199'', E 069 08' 959''	16-6-07 19-6-07 14-10-07 16-10-07
2	*Midge flee*	Goth Urs Junejo N 26 06' 288'', E 69 09' 181'' N 26 11' 638'', E 069 03' 628'' N 26 06' 706'' , E069 09' 334'' N 26 08' 199'', E 069 08' 959'' N 26 07' 757'', E 069 09' 228''	 17-06-07 14-10-07 15-10-07 16-10-07 16-10-07
3	*Oligochaeta*	N 26 06' 513'', E 069 08' 014''	18-6-07 16-10-07
4	*Mosquito larvae*	N 26 07' 757'' , E 069 09' 228'' Goth Sobharo Mallah: N 26 08' 199'', E 069 08' 959'' N 26 06' 513'', E 069 08 014 N 26 10' 705'', E 069 06' 843''	19-06-07 19-06-07 14-10-07 15-10-07

During the winter survey, which started from 14 to 17 November 2007 the adult micro-invertebrate population was found to be much lower at all sampling spots as compared to the summer visit. Most of the samples collected included the larvae pertaining to various dipteran groups. The main reason is that most of the invertebrate groups are in their early developmental stages during the winter and the therefore their adult populations are missing or are scarce. The other significant reason is the diapause during which some of these groups undergo dormancy. The underlying fact that at similar environmental conditions various groups of invertebrates undergo diverse physiological variations other than diapause, thus few are more abundant than the others at a particular season of the year. The different seasons of the year also plays a key role in the differences in abundance and diversity of these micro-invertebrates at Chotiari reservoir.

The water is mainly lentic in most parts of the reservoir thus supporting the growth and proliferation of phytoplankton that serve as the base of the aquatic food web, providing an essential ecological function for aquatic life. The phytoplankton found in abundance in the reservoir indicates the health of primary productivity and therefore provide ample food for the invertebrate fauna that depend on these phytoplankton population. The lentic water at different sites also supports various insect larvae undergoing developmental stages at the surface of water.

In both the surveys the sampling for invertebrates was done at every significant site of the reservoir. There is a great abundance of insect larvae with a significantly greater population of mosquito larvae growing on the surface of the lentic waters at various places of the reservoir thus providing an excellent food source for the mosquito-eating fish.

3.7.3 Aquatic micro-invertebrates found in Chotiari Reservoir

3.7.3.1 Midge fly

Midge fly larvae were very abundant in Chotiari reservoir and at various places in the reservoir. Adequate sampling of these was done during the summer as well as the winter survey using plankton net. A moderate population of midge fly larvae was observed and caught in Chotiari reservoir during the summer as well though the Number of these larvae was much more plentiful during the winter. These flies are usually found in all but the most polluted aquatic conditions. The presence of Midge flies in large numbers indicates that there is an organic enrichment in the water body that they dwell in. This also indicates that the effect of pollutants, human waste and other effluents getting added in to the Reservoir has not yet turned drastic in terms of its damaging effect on the micro-invertebrate population of the Reservoir.

3.7.3.2Oligochaeta

A small but frequent population of Oligochaetes was found in the reservoir during both the seasons.

3.7.3.3 Ecological role of Oligochaetes

Oligochaetes are usually collectors, feeding on the dead organic material and bacteria in the sediment. Microdriles occur in running and still waters including, oligotrophic lakes and streams, organically enriched wetlands, and groundwater. They are found in or on the substratum. Species with gills are found in tubes made of silt or mud with the posterior end of the worm protruding into the water. Species without gills may be found in small burrows. The smaller Naididae species swim just above the substratum with body undulations. Most other aquatic oligochaetes crawl along the substratum with peristaltic motions, side-to-side body movements and slight extensions and retractions of setae.

Image 13: Oligochaeta

Aquatic worms ingest large amounts of the substratum, feeding on organic material (diatoms, algal, plant) and bacteria in silt and mud. A few species of Naididae may be carnivorous, with Chaetogaster limnaei (Naididae) being endo-parasitic in the kidney of freshwater snails. Most microdriles undergo respiratory exchange of gases at the body surface across the thin body wall. However, some Naididae and Tubificidae species exhibit anal peristalsis where water is drawn into the posterior part of the gut for a short period for exchange of gases.

Oligochaetes are hermaphrodites that undergo sexual reproduction with cross fertilization (or occasionally self fertilization). A cocoon is formed from the clitellum into which fertilized eggs are deposited. Cocoons may be fastened to submerged objects or left free in the water or sediment. There are no larval stages. Naididae species reproduce by a process of budding from a special segment. The budding segment is located towards the posterior end of the worm. During the budding process, it proliferates anteriorly to form a new hind region for the parent worm, and posteriorly to form an anterior region for the offspring. Offspring and parent may remain attached for some time and the offspring may even bud while still attached.

Oligochaetes are important primary consumers in many systems, where they are important in the early links of some food chains. The importance of these soft-bodied worms in diets is often underestimated. Some are used as commercial fish food. They are often largely responsible for the bioturbation of lake sediments and where they can affect nutrient dynamics of the system. Some are good environmental indicators, especially the Tubificidae. Some are secondary hosts for important parasites.

3.7.3.4 Rotifera

In Chotiari reservoir a very small population of rotifers was found in the early summer of 2007 and even smaller population was observed during the winter survey the same year. Zooplankton specimens captured during sampling from the Chotiari Reservoir were studied and found to belong to the a few genera of the Phylum Rotifera out of which most of the identified specimens belonged to the family Brachionidae. There were at least more than three distinct species in the pool of collection taken from Chotiari reservoir but as no reliable key is available regarding the identification of these rotifers up to the species level, the identification was, therefore, done up to the lowest possible taxonomic level.

Phylum Rotifera **Class Monogonata** **Order Ploima** **Family Brachionidae** **Genus** *Platyias*
Phylum Rotifera **Class Monogonata** **Order Ploima** **Family: Brachionidae** **Genus:** *Keratella*

3.7.3.5 Ecological role of rotifers

Rotifers play a major role in freshwater ecosystems; their abundance and ubiquitous occurrence rank them as one of the most basic building blocks of aquatic food webs. Within these webs, they are not only numerous but occupy a diversity of trophic levels. Currently the state of rotifer taxonomy suffers in comparison to the ecological importance of these organisms.

3.7.4 Some terrestrial invertebrates

3.7.4.1 Class Arachnida

Arachnids comprise a Class of Chelicerata, a major Subphylum of the Phylum Arthropoda. Arachnids include over 70,000 described species (and most likely a very large number of so-far un-described ones). Spiders make up the majority of these with mites and ticks next largest. The Arachnids include a diverse array of smaller groups, including scorpions (1200 species), whip scorpions, palpigrades, pseudoscorpions, solpugids and harvestmen characterized by four pairs of segmented legs and a body that is divided into two regions, the cephalothorax and the abdomen. Nearly all species are terrestrial. Arachnids are found worldwide in nearly every habitat.

Arachnids have a pair of tagmata called a prosoma and opisthosoma. The prosoma is partially or completely covered with a carapace-like shield. The opisthosoma may be segmented or unsegmented. The appendages on the opithosoma are absent or modified, being used as spinnerets (spiders) or pectines (probably sensory in function, found in scorpions). Respiration is via tracheae or book lungs; it is cutaneous in many small arachnids.

3.7.4.2 Order Solifugae

A few solifugids specimens belonging to the following taxonomic hierarchy were captured from the adjoining areas of the Chotiari reservoir.

3.7.4.3 Ecological role of Solifugids

Solifugids are known as the dominant predatory arachnids in the arid ecosystems. They also survive in extreme arid ecosystems where there is little vegetation (e.g., rocky habitats and dune systems), and serve as important prey for such vertebrates existing in these habitats (Punzo 1998). Schmoller (1970) and Cloudsley-Thompson (1962, 1970) considered solifugids indicator species for desert environments. Living in these arid environments, solifugids are subjected to very high daytime temperatures, low nighttime temperatures and relatively low humidity. They, however, have high metabolic rate, which bestows them a high voracity for predation. Most aspects of their interesting physiology in these extreme ecosystems remain to be explored.

3.7.4.4 Araneae

A number of spiders captured from the adjoining areas of the Chotiari Reservoir were catalogued and identified at the genus level. Following is their taxonomic hierarchy. There is a very diverse and healthy population of spiders belonging to various families in the vicinity of both study areas.

3.7.4.5 Genus *Arctosa*

Five specimens of the genus Arctosa were captured and identified and catalogued from the Chotiari reservoir. The carapace lacked a definite median band. Their legs were clearly spotted. Most species make burrows in the sand, moss or detritus. The length of most of the spiders was between 10 – 15 mm.

Image 14: Araneae

3.7.4.6 Genus *Pardosa*

This is the most abundant genus with 39 species. They are found running on the ground in sunny warm places. When the weather conditions are poor they hide among the leaves, moss and detritus. In the vicinity of the Pai forest, two specimens of genus *pardosa* were captured. The females belonging to the genus *Pardosa* were seen with their egg sacs attaches to their spinners. After 2 or 3 weeks the sac is opened and the spiderlings crawl on top of the abdomen of the mother where they travel with her for about a week. A female may have two or three sacs a year. Their size varies between 4 and 8 mm.

Table 23 – Genus of zooplankton species in Chotiari reservoir

No.	Phylum	Class	Order	Suborder	Family	Genus
1	Arthropoda	Arachnida	Araneae	Neocribellatae	Lycosidae	*Arctosa*
2						*Pardosa*
3					Gnaphosidae	*Zelotus*
4					Neocribellatae	*Nephila*

3.7.5 Threats and discussion

No threats or recommendations were submitted with the study report. However the author did point out that while studying the invertebrate fauna of an area, different sampling gear and different approaches of sampling have different biases. Absolute accuracy of the diversity and abundance is difficult to determine because the only baseline for comparison is often our own samples. The researcher should therefore be familiar with the bias inherent in the individual sampling gear and analyses. Sampling at each station with a wide variety of sizes of nets and meshes, for example, significantly increases precision in the study of invertebrates.

The present study, like most of the invertebrate studies conducted elsewhere, was biased by the sampling program and the equipment. Another postulation is the inherent assumption of an even distribution of the sub sampled population, which is mostly rare, because of the patchy distribution of zooplankton. Comparing with the huge availability of both terrestrial and aquatic invertebrates in and around the lake, the temporal scale was also biased rather limited as the survey was carried on for five days. The samples collected were sufficient, however, to describe what was present at the times sampled. Temporal variations and seasonality in the abundance of zooplanktons have been observed all over the world. Some of these variations are possibly due *en route* for the year- to-year variability in environmental factors. The species diversity tends to be low in stressed and polluted ecosystems.

3.8 Physico-chemical properties of water

3.8.1 Sampling locations

Map 10 shows the sampling locations for water sampling from Chotiari Reservoir

Map 10 – showing the sampling locations for water quality from Chotiari Reservoir

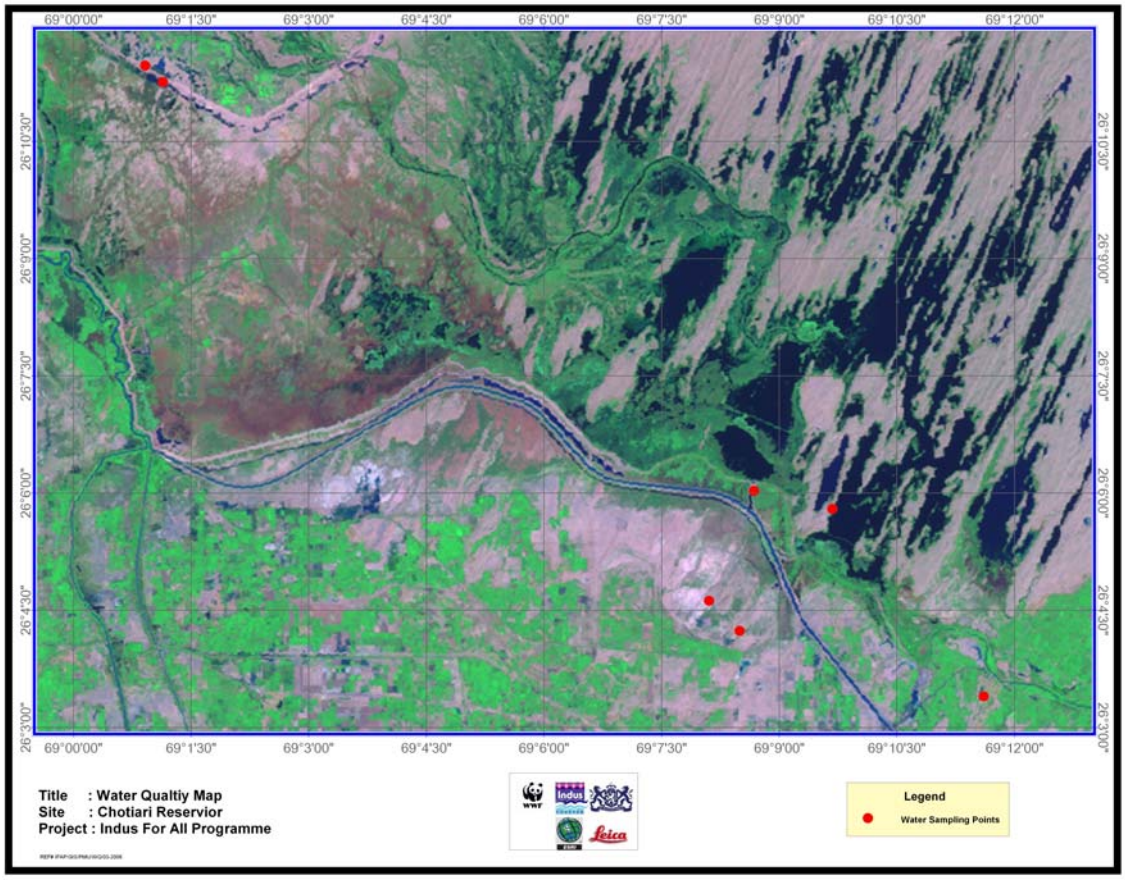


Table 24 – Significance of sample location points

Sample number	Sample Location	Geographical location	Significance
CR-B1	In side reservoir RD-157	N2606026 E6908678	South side (To get overall picture of the water quality in the reservoir south and north sides samples were taken)
CR-B3	Bakar Lake: Near Haji Islam Larik village	N2605795 E6909679	This lake has been disconnected from the fresh water coming from the Ranto canal of Indus river off taking from Nara Canal. The lake is getting seepage water.
CR- B4	Dogrion Lake	N2604621 E6908106	This lake has developed after the reservoir construction and water quality is changing from last few years as reported by community due to seepage water coming from main reservoir
CR-B5	Village Mungria-Hand pump	N2604234 E6908497	Water quality has deteriorated due to seepage coming from the reservoir as reported by the community.
CR-B6	Chotiari City: Hand pump	N2603397 E6911608	Water quality is brackish after 2002 (inception year of the reservoir) as reported by the local affected community and verified physically.
CR-B7	In side Chotiari at RD-55,	N2611468 E6900915	Western side: This location represents the other side of the reservoir where seepage water is being collected through open drain for pumping back in to the reservoir.
CR-B8	Outside Chotiari reservoir at RD-55	N2611468 E6900915	This sampling point represents the seepage water coming from the reservoir which is ultimately being pumped back in to the reservoir at pumping station.
CR- B9	Pumping station	n/a	The seepage from the reservoir and from the adjacent agriculture area is drained through surface drains and then pumped back into the reservoir
CR-B10	Village Sono Rajar	n/a	Influence of reservoir on groundwater (GW)
CR-B11	Padhrio lake	n/a	Highly saline lake inside reservoir- The consideration to this point was given because the rise of water level in the reservoir may join this lake and may degrade the overall quality of the reservoir.
CR-B12	Sabbojho village	n/a	Well water

3.8.2 Observations during field investigation

There are approximately 60 villages with a population of 16,000 which is directly and indirectly dependent on the natural resources of the reservoir. The economy of the area is mostly on fishing, agriculture and livestock. Women are largely involved in agriculture, livestock, fishing and household activities.

The seepage water was observed in the surrounding of the reservoir. This seepage mostly takes place from western and southern sides of the reservoir. Agriculture was observed on the western and southern side of the reservoir. This large seepage has compelled farmer communities to leave the area, resulting in loss of livelihood. Although the district government has decided to remove the

seepage water by pumping back in to the reservoir, however there is need to find a sustainable way for the water to flow back from the reservoir boundary to save agriculture from devastation.

The northern side of the reservoir seems to be favorable for livestock. The development of the lake for storing more water for agriculture has reduced the existing rangeland for grazing of the livestock. Here livestock and dairy farm may be established to provide the livelihood source to the framers who have lost their agriculture land.

The water quality of the main reservoir is very good. The Bakar Lake is situated on the east of reservoir near Islam Larik village. The large population of villages and agriculture are concentrated on the southern side of the reservoir. The groundwater of Dongrion, Mangria and Chotiari villages was physical observed as highly saline water.

Three lakes were visited during the surveys which are in the surrounding areas of the reservoir. All these three lakes: Bakar, Dongrion, Mangria are highly saline having TDS varying from 3000 to 9000 mg/l. This water is neither suitable for fish nor for livestock and agriculture. The quality of these three lakes water needs to be checked for any Catastrophe, which may occur.

The health related issues were also noticed in the field area. The major complain was the Hepatitis inflicted by the saline ground water. The hand pump water was therefore collected from few villages to check this water and also find arsenic contamination. The influence of reservoir seepage on groundwater is occurring. There is need to conduct a comprehensive study to check level of seepage to ascertain the potential threat areas for its control and/or for rehabilitation.

3.8.3 Results and discussion

Water samples of Chotiari Reservoir study area were collected from different potential locations pre monsoon in July 2007 and post monsoon in October/November 2007. These location points are covering main reservoir, surrounding lakes and groundwater from the neighboring villages.

For the sake of brevity the water quality results are given below for the purpose of its use as drinking, agriculture and fishing against the WHO and other important water quality guidelines/standards. Only important sample locations and water quality parameters, assessed in this study, are elaborated. The data assessed is presented as physical and chemical parameters. **Table 25** and **26** show the physical and chemical parameters for pre and post monsoon water quality at Chotiari Reservoir.

Table 25 – Physical and chemical parameters – pre-monsoon

	Parameters	Pre monsoon
1	Temperature	30-32°C
2	Electrical Conductivity	553-39500 µS/cm
3	TDS	354-25280 ppm
4	pH	7.3-8.9
5	Turbidity	0.83-17.5 NTU
6	Total Hardness	100-3450 ppm
7	Calcium	50-1600 ppm.
8	Magnesium	40-3400 ppm
9	Sulphate	75-3450 ppm.
10	Chlorine	150 -14000 ppm.
11	Alkalinity	30-330 ppm
12	Phenols	6.8-510ppb
13	DO	0.18 to 4.92 mg/l

Table 26 – Physical and chemical parameters – post-monsoon

	Parameters	Post monsoon
1	Temperature	25-29°C.
2	Electrical Conductivity	571-15400 µS/cm.
3	TDS	366-9856 ppm
4	pH	7.20-8.36
5	Turbidity	2.00-40.0
6	Total Hardness	105-3000 ppm
7	Calcium	40-310 ppm.
8	Magnesium	65-2690 ppm
9	Sulphate	62-1125 ppm
10	Chlorine	100-2250 ppm
11	Alkalinity	80-460 ppm.
12	Phenols	5.1-74.8ppb
13	Nitrates	0.182 and 0.345 mg/l.
14	Phosphate	0.42 and 0.52 mg/l.
15	DO	1.5 to 3.2 mg/l
16	BOD	1.76-4.58 ppm
17	COD	5.16-11.15 ppm
18	Cr	30-72.6 ppb
19	Pb	6.82-14.6 ppb
20	Cd	0.66-2.45 ppb.
21	Ni	2.32-9.59 ppm
22	Arsenic	25-50 ppb

3.8.4 Drinking Water

The drinking water quality is judged by comparing the results with the WHO drinking water quality Standards. The main reservoir data show that the water quality is fit for drinking according to the WHO standards. However, some parameters such as Cr, Ni and Phenol were a little excessive than the recommended guideline values. It seems that the Indus River water coming from upstream contains these contaminants because no other pollutant sources are seen. The TDS, pH and DO are within WHO guidelines. The COD and BOD values are slightly higher indicating some organic pollution coming from the

upstream of the Indus River water. The CR-B8 is showing high value of TDS, pH, Cl, and Mg which is attributed to seepage water.

The groundwater samples collected from the surrounding area of the reservoir have shown that the quality is very poor. All the assessed parameters are violating the WHO drinking water guidelines. The Arsenic has been particularly observed in the groundwater which shows higher value than the recommended WHO guidelines. It is noteworthy to mention that no significant change is observed in two data sets particularly for groundwater quality (Pre and post monsoon).

The lakes which are in the study area and are affected by the reservoir have no access of Indus River and that all are getting seepage water from the reservoir and rain water. The water quality confirms that it is not suitable for drinking and contains high TDS and salts of magnesium and calcium chlorides/sulphates. These lakes receive less rain water hence no major change is observed in water quality data sets of both before and after monsoon periods.

3.8.5 Agriculture and livestock

The water quality of the reservoir is very good, considering the TDS (<500 mg/l, and pH (6.5-8.50). According to FAO Standards for agriculture crops, it appears that None Degree of Restriction of Use is applicable for agriculture crops, as it receives regular fresh water from the Nara Canal through Raunto Canal. The water salinity (TDS) of the reservoir is well below 1000 mg/l, which is excellent for all livestock and poultry as per FAO guidelines. The Bakar lake water is satisfactory for the use of livestock and poultry, however, the other two lakes: Dongrion and Patherio water is unfit for livestock and poultry. The groundwater is also unfit for agriculture and poultry but can be used for livestock. It is also noticed that there is no significant change in most of the parameters before and after monsoon period.

3.8.6 Fisheries

The minimum Dissolved Oxygen (DO) level that fish can safely tolerate depends upon temperature and to some extent the specie types. As a rule of thumb, Dissolved Oxygen (DO) should be maintained above 3.0 mg/l for warm water fish and 5.0 mg/l for cold water fish. Prolonged exposure to low, non -lethal levels of DO constitute a chronic stress and will cause fish to stop feeding, reduce their ability to convert ingested food in to fish flesh, and make them more susceptible to disease.

The good quality surface water normally have dissolved oxygen as high as 9 mg/l (depending upon pH and temperature).The dissolved oxygen is found above 3.0 mg/l, Phenol within acceptable limit of 0.02 mg/l. Lead level is also less than 0.1 mg/l. All these parameters along with TDS (less than 1000 mg/l) are sufficiently supporting to fish culture. It is also observed that the phenols have decreased to some extent after rain fall.

The water quality of Bakar Lake in terms of TDS, Phenol and Lead is suitable for fish development. However, the DO is at the marginal level and fluctuates around 2.0 mg/l. The water quality of Dongrion and Patherio Lakes is hazardous for fishery in light of above parameters.

Table 27 – Chotiari Reservoir water quality assessment (pre-monsoon - main reservoir area)

	Parameter	Permissible WHO Standards	CR-B1	CR-B7	CR-B8	CR-B9	Remarks
1	TDS (mg/l	1000	354	588	1188	923	CR-B8 high
2	pH	6.5-8.5	7.9	8.1	8.9	7.6	CR-B8 Out of range
3	Turbidity (NUT)	5	1.51	1.80	1.20	0.93	normal
4	Total Hardness (mg/l)	500	170±0.1	185±0.05	300±0.06	150±0.03	normal
5	SO_4 (mg/l)	250	75±0.05	187±0.05	250±0.02	125±0.02	normal
6	Cl (mg/l)	250	150±0.2	215±0.1	500±0.3	360±0.2	CR-B8 high
7	Magnesium (mg/l)	150	60±0.12	135±0.11	210±0.11	55±0.13	CR-B8 high
8	Calcium (mg/l)	75	110±0.12	50±0.11	90±0.11	95±0.13	Slightly high
9	DO (mg/l)	>2mg/l	5.06	4.92	2.65	3.12	normal
10	Phenol (µg/l)	0.002 mg/l	17	17	34	6.8	High in all, very high in CR-B8

The ± values show the standard deviation

Table 28 – Chotiari Reservoir water quality assessment (pre-monsoon groundwater surrounding Chotiari Reservoir)

	Parameter	Permissible WHO Standards	CR-B5	CR-B6	CR-B10	CR-B12	Remarks
1	TDS (mg/l	1000	9216	3609	1658	5670	All are high, except CR-B10 which is marginally good
2	pH	6.5-8.5	7.30	7.5	7.6	8.4	normal
3	Turbidity (NUT)	5	1.46	0.83	1.55	17.5	CR- B12 high
4	Total Hardness (mg/l)	500	1800±0.09	800±0.07	100±0.03	500±0.05	CR-B6 high CR-B5,very high
5	SO_4 (mg/l)	250	1000±0.1	1200±0.1	500±0.03	1000±0.05	All very high
6	Cl^- (mg/l)	250	6000±0.4	1500±0.2	950±0.05	1980±0.2	All very high
7	Magnesium (mg/l)	150	1480±0.12	600±0.10	40±0.20	330±0.15	All very high except

							CR-B10
8	Calcium (mg/l)	75	320±0.12	200±0.10	60±0.02	170±0.15	All very high except CR-B10
9	DO(mg/l)	>2mg/l	3.61	3.74	0.91	0.18	CR-B10,12 low
10	Phenol (µg/l)	0.002 mg/l	2.2	85	11.9	17	All are high

The ± values show the standard deviation

Table 29 – Chotiari Reservoir water quality assessment (pre-monsoon lakes surrounding Chotiari Reservoir)

S.no	Parameter	Permissible WHO Standards	CR-B3	CR-B4	CR-B11	Remarks
1	TDS (mg/l	1000	4006	17280	25280	All high, CR-B11 very high
2	pH	6.5-8.5	7.7	8.3	7.5	Normal
3	Turbidity (NTU)	5	1.05	7.96	1.16	Normal
4	Total Hardness (mg/l)	500	650±0.11	3450±0.12	5000±0.1	CR-B4,11 very high
5	SO_4 (mg/l)	250	750±0.1	3450±0.2	2500±0.05	CR-B4,11 very high
6	Cl^- (mg/l)	250	2300±0.5	10000±0.5	1400±0.2	High
7	Magnesium (mg/l)	150	400±0.10	1150±0.15	3400±0.25	High
8	Calcium (mg/l)	75	250±0.10	2300±0.15	1600±0.25	High
9	DO(mg/l)	>2mg/l	2.4	1.37	1.47	CR-B4,11 low
10	Phenol (µg/l)	0.002	34	68	34	All high

The ± values show the standard deviation

Table 30 – Chotiari Reservoir water quality assessment (post-monsoon main reservoir)

S.no	Parameter	Permissible WHO Standards	CR-A1	CR-A 7	CR-A8	CR-A9	Remarks
1	TDS (mg/l	1000	366.0	902.0	909	1045	normal
2	pH	6.5-8.5	7.75	8.36	7.8	8.0	normal
3	Turbidity (NTU)	5	8.60	40.0		23.0	CR-A7,9 high
4	Total Hardness (mg/l)	500	105±0.15	300±0.11	280	190±0.15	normal
5	SO_4 (mg/l)	250	62±0.25	125±0.33		150±20	normal
6	Cl (mg/l)	250	100±0.12	205±0.18	209	325±0.22	normal
7	Magnesium (mg/l)	150	65±0.2	230±0.23	38	108±0.23	CR-A 7

							little high
8	Calcium (mg/l)	75	40±0.2	70±0.23	84	82±0.23	normal
9	COD		6.06	9.46		11.15	CR-A7,9 high
10	BOD(mg/l)		1.76	4.07		4.58	
11	Phenol (µg/l)	0.002	5.1	6.8		8.5	Little high
12	Cr (µg/l)	0.05	72.6	48.9		68.3	high
13	Cd (µg/l)	0.003	0.66	1.13		1.49	normal
14	Pb (µg/l)	0.01	6.82	9.02		11.3	normal
15	Ni (mg/l)	0.02	2.32	4.93		4.48S	high
16	NO_3	50 mg/l	-	-	Nil	-	Not found
17	DO(mg/l)	>2mg/l	3.2	2.5	5.2		normal
18	Phosphate				0.52		

The ± values show the standard deviation

Table 31 – Chotiari Reservoir water quality assessment (post-monsoon groundwater surrounding the Reservoir)

S.no	Parameter	Permissible WHO Standards	CR-A 5	CR-A 6	CR-A10	CR-A12	Remarks
1	TDS (mg/l	1000	9856	3776	1600	5520	High, CR-A5 very high
2	pH	6.5-8.5	7.20	7.29	7.55	8.12	normal
3	Turbidity (NTU)	5	30.0	2.00	1.45	10.5	CR-A5, A12 very high
4	Total Hardness (mg/l)	500	3000±0.20	700±0.10	98±0.04	430±0.04	CR-A5 very high
5	SO_4 (mg/l)	250	1025±0.25	1125±0.30	435±0.05	980±0.03	High
6	Cl (mg/l)	250	4300±0.20	1000±0.15	870±0.03	1790±0.2	High,CR-A5 very high
7	Magnesium (mg/l)	150	2690±0.25	400±0.20	35±0.20	320±0.10	High,CR-A5 very high
8	Calcium (mg/l)	75	310±0.15	300±0.20	65±0.04	155±0.15	High, but CR-A10 normal
9	DO(mg/l)	>2mg/l	2.3	2.0	0.82	0.20	Normal, CR-A10,12 less
10	COD		7.83	7.07			
11	BOD(mg/l)		2.05	2.02			normal
12	Phenol (µg/l)	0.002 mg/l	74.8	37.5	10.2	15	High, CR-A5 very high
13	Cr (µg/l)	0.05 mg/l	91.9	30.9			CR-A5 high
14	Cd (µg/l)	0.003 mg/l	2.45	0.39			Normal
15	Pb (µg/l)	0.01 mg/l	6.85	18.3			Normal
16	Ni (mg/l)	0.02 mg/l	9.59	6.39			High
17	NO^3 (mg/l)	50 mg/l		0.345			Normal
18	As (µg/l)	0.01	25	50			High

The ± values show the standard deviation

Table 32 – Chotiari reservoir water quality assessment (post-monsoon lakes surrounding the Reservoir)

S.no	Parameter	Permissible WHO Standards	CR-A 3	CR-A4	CR-A11	Remarks
1	TDS (mg/l	1000	4423	11784	23528	High
2	pH	6.5-8.5	7.84	7.9	7.2	Normal
3	Turbidity (NUT)	5	6.4		2.15	Normal
4	Total Hardness (mg/l)	500	680±0.20	2980	4800±0.1	High
5	SO_4 (mg/l)	250	162±0.25		2425±0.04	Normal/High
6	Cl (mg/l)	250	2250±0.15	5623	1350±0.25	High
7	Magnesium (mg/l)	150	470±0.2	518	3350±0.20	High
8	Calcium (mg/l)	75	210±0.2	332	1550±0.30	High
9	DO (mg/l)	>2mg/l	1.5	4.0	1.40	Less in CR-A3, A11
10	COD(mg/l)		5.16			Normal
11	BOD(mg/l)		1.88			Normal
12	Phenol (µg/l)	0.002 (mg/l)	23.8		29	High
13	Cr (µg/l)	0.05(mg/l)	49.6			Normal
14	Cd (µg/l)	0.003(mg/l)	1.64			Normal
15	Pb (µg/l)	0.01(mg/l)	14.6			Normal
16	Ni (mg/l)	0.02(mg/l)	6.51			High
17	NO^3(mg/l)	50 mg/l	0.182			low
18	Phosphate			0.42		

The ± values show the standard deviation

3.8.7 Threats and recommendations

No threats have been identified by the consultant however the following comments and recommendations have been given.

The baseline data have been developed and could be used as a reference point. However, the data collected for two times (Before and after monsoon) may not be enough to develop solid recommendations. From this study it is concluded that the monitoring strategy may be devised to cover the following aspects.

- **Reservoir water quality:**
  The periodic water quality monitoring programme may be initiated. This monitoring programme should be on bi-annual basis and the recording period should be during flood time (August) and after flood period (February).

- **Seepage influence:**
  The major environmental degradation is occurring due to seepage from the reservoir. Therefore, series of piezometers should be installed at various locations to observe the vertical and horizontal movement of seepage water.

Pumping of seepage water back in to the reservoir is not a viable solution and is a risk to the survival of the reservoir and its natural habitats. Also, it is difficult to keep the pumping station functional on one hand and on the other hand it requires lot of cost to operate and maintain it. The sustainable approach would be to construct surface drainage system and to throw seepage water out of the Chotiari Reservoir catchments area.

Chapter 4: Comparison of the four study sites

4.1 Mammals

4.1.1 Summary

There is no significant difference in results of the summer and winter surveys of the study areas. The same 20 species were recorded from the study areas during both the surveys. However, during the winter survey, the population of Hump-back dolphin was larger in different creeks at Keti Bunder. This is probably due to the availability of fish which they feed on. Moreover, most of the mammals particularly the nocturnal mammals were found more active during the summer survey and less active comparatively during the winter survey. The reasons seem to be the homoeothermy and the hibernation factors for less activeness of mammals during winter.

The existence of Indian otter was doubtful in Chotiari Reservoir prior to these studies. During the present surveys both in summer and winter, the existence of this animal was confirmed in Chotiari Reservoir and Keti Shah and its population was estimated at both the sites.

Estimated populations of mammals at different sites during two different surveys do not show any significant differences. For example, Hog deer population at Pai forest estimated during the summer survey was 18 animals whereas estimates during winter survey showed a population of 20 animals. During the summer survey 7 otters were estimated at Chotiari Reservoir but during winter survey about 12 animals were estimated. However, the locations where the otters were found during the summer survey were different from the locations during winter surveys. The locations along Nara canal where otters were found during summer survey showed no sign of otters during winter survey as the Nara canal was dry during winter survey. It shows that food availability, shelter and health of the habitat are the main factors.

Local people as well as most of the conservationists believed that there exists the Asiatic wild ass in north eastern side of Chotiari reservoir. The present studies revealed that the existing population is apparently the feral donkeys known as “Asses of Achhro Thar” and not the Asiatic wild ass. There is close resemblance of these animals with the Asiatic wild ass and their coexistence in the same habitat with the Asiatic Wild Ass for the last 7 decades. Investigation through genomic studies is trying to identify if these animals are wild asses, feral donkeys or some race of the Asiatic wild ass. In this regard a genomic analysis of all the three races will clearly suggest that either the Asses of Achhro Thar are feral donkeys or they are a separate race or subspecies. Concerns about wild animals among the local residents are not much severe.

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 populations.

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 of *Indus for All Programme* 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 etc. at different sites are also important factors in wildlife conservation and management in the study area.

4.1.2 Species identified

Over 40 days in the field (21 days during summer in June 2007 and 22 days during winter in January 2008) a total of 20 large and medium sized mammal species, belonging to five orders (Carnivora, Artiodactyla, Perissodactyla, Cetacea and Pholidota) were recorded from the five sites of Indus for All Programme. Eight species were recorded from Pai forest, 14 from Chotiari, 9 from Keenjhar, 14 from Keti Bunder and 8 from Keti Shah. **Table 33** lists all the species recorded over the survey period.

Table 33 – Species recorded from different sites

S.no	Common Name	Zoological Name	Local Name	Order
1	Asiatic jackal	*Canis aureus*	Geedar/Giddar	Carnivora
2	Caracal or Desert lynx	*Felis caracal*	Siva gush	Carnivora
3	Jungle cat	*Felis chaus*	Jang Billo	Carnivora
4	Fishing cat	*Prionailurus viverrinus*	Mash Billo	Carnivora
5	Indian desert cat	*Felis sylvestris ornata*	Sahrai Billi	Carnivora
6	Bengal fox	*Vulpes bengalensis*	Lumar	Carnivora
7	Desert fox or Red fox	*Vulpes vulpes pusilla*	Sahrai Lumar	Carnivora
8	Indian otter	*Lutrogale perspicillata*	Ludher	Carnivora
9	Small Indian mongoose	*Herpestes javanicus*	Neola	Carnivora
10	Grey mongoose	*Herpestes edwardsi*	Neola	Carnivora
11	Small Indian civet	*Viverricula indica*	Kasturi Billa	Carnivora
12	Hog deer	*Axis porcinus*	Para	Artiodactyla
13	Indian wild boar	*Sus scrofa*	Suar	Artiodactyla
14	Chinkara	*Gazella bennettii*	Chitka Hiran	Artiodactyla
15	Feral donkey	*Equus sp.*	Jangli Gadha	Perissodactyla
16	Indus dolphin	*Platanista minor*	Bhulan	Cetacea
17	Bottle-nosed dolphin	*Tursiops truncatus*	Malhar	Cetacea
18	Hump-backed dolphin	*Sousa chinensis*	Humma	Cetacea
19	Finless porpoise	*Neophocaena hocaenoides*	Tabi	Cetacea
20	Indian pangolin	*Manis crassicaudata*	Bagra, Silu	Pholidota

4.1.3 Observation records

Out of the total 20 recorded species, 15 species were observed directly while the remaining five 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 **Table 34**.

Table 34 – Observation records of different mammals at sites

Sr. No.	Species	Direct Observations					Indirect observations through tracks, faeces and interviews from locals Residents				
		KB	K	P	C	KS	KB	K	P	C	KS
1	Asiatic jackal	✓	✓	✓	✓	-	-	-	-	-	✓
2	Caracal	-	-	-	-	-	-	-	-	✓	-
3	Jungle cat	-	-	-	✓	-	✓	✓	✓	✓	✓
4	Fishing cat	-	-	-	-	-	✓	✓	-	✓	-
5	Indian desert cat	-	-	-	-	-	✓	-	-	✓	-
6	Bengal fox	✓	-	-	✓	-	✓	✓	✓	✓	-
7	Desert fox	-	-	-	✓	-	✓	✓	-	✓	-
8	Indian otter	-	-	-	-	-	-	-	-	✓	-
9	Small mongoose	✓	✓	✓	✓	-	-	-	-	-	✓
10	Grey mongoose	-	-	✓	✓	-	-	-	-	-	✓
11	Small Indian civet	✓	-	✓	-	-	-	-	-	-	✓
12	Hog deer	-	-	✓	-	-	-	-	✓	✓	✓
13	Indian wild boar	-	✓	-	-	-	✓	✓	✓	✓	✓
14	Chinkara	-	-	-	✓	-	-	-	-	✓	-
15	Feral donkey	-	-	-	✓	-	-	-	-	✓	-
16	Indus dolphin	-	-	-	-	✓	-	-	-	-	-
17	Bottle-nosed dolphin	✓	-	-	-	-	-	-	-	-	-
18	Hump-backed dolphin	✓	-	-	-	-	-	-	-	-	-
19	Finless porpoise	✓	-	-	-	-	-	-	-	-	-
20	Indian pangolin	-	-	-	-	-	✓	✓	-	-	-
Legend: KB = Keti Bunder, K=Keenjhar, P=Pai Forest, C=Chotiari, KS=Keti Shah											

4.1.4 Conservation status of mammal species

According to the IUCN International Red List 2006, Jungle cat, Small Indian mongoose and Small Indian civet are categorized as Least Concern (LC), Fishing cat as Vulnerable (VU) and Finless porpoise as Data Deficient (DD).

According to the Pakistan IUCN Red List of Mammals 2005, one species is Critically Endangered (CE), one Endangered (E), three Vulnerable (VU), six Near Threatened (NT), four Least Concern (LC) and four Data Deficient (DD).

Ten species are protected in Sindh under Sindh Wildlife Protection Ordinance 1972. Three species are enlisted in Appendix II while six species in Appendix I of the CITES category 2007. The conservation status of different mammals found at Indus for All Programme sites is given in **Table 35** below.

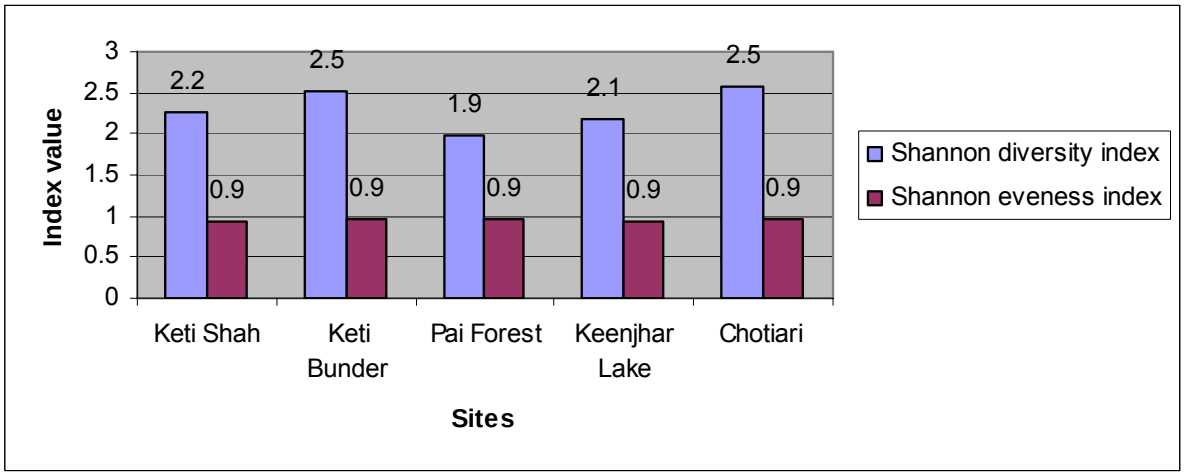
Table 35 – Conservation status of mammals found at Indus for All Programme sites

Sr. No.	Mammalian Species Recorded	IUCN International Red List 2006	IUCN Pakistan Red List 2005	Sindh Wildlife Protection Ordinance 1972	CITES Category 2007
1	Asiatic jackal	-	NT	-	-
2	Caracal or Desert lynx	-	CE	P	Appendix I
3	Jungle cat	LC	LC	P	Appendix II
4	Fishing cat	VU	NT	P	Appendix II
5	Indian desert cat	-	DD	P	Appendix II
6	Bengal fox	-	NT	-	-
7	Desert fox / Red fox	-	NT	-	-
8	Indian otter	-	NT	P	-
9	Small Indian mongoose	LC	LC	-	-
10	Grey mongoose	-	LC	-	-
11	Small Indian civet	LC	NT	P	-
12	Hog deer	-	VU	P	Appendix I
13	Indian wild boar	-	LC	-	-
14	Chinkara	-	VU	P	-
15	Feral donkey	-	-	-	-
16	Indus dolphin	-	E	P	Appendix I
17	Bottle-nosed dolphin	-	DD	-	Appendix I
18	Hump-backed dolphin	-	DD	-	Appendix I
19	Finless porpoise	DD	DD	-	Appendix I
20	Indian pangolin	-	VU	P	-
Legend: CE=Critically Endangered, E=Endangered VU=Vulnerable, NT=Near Threatened, LC=Least Concern, DD=Data Deficient, P=Protected					

4.1.5 Species diversity

Looking at the diversity index over the four sites (shown in **Figure 19**) Chotiari Reservoir holds the highest level of diversity of mammals followed by Keti Bunder. Given the variety of habitats at Chotiari Reservoir (desert, wetland and forest) it is not surprising that this site holds the highest index. Similarly, Keti Bunder comprises of both terrestrial and marine habitats which results in a high diversity index despite apparent environmental 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 Chotiari Reservoir. These indexes do not take into account the diversity across seasons, something that is discussed further on in this chapter.

Figure 19 – Shannon diversity and evenness index over the programme sites



4.1.6 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 36 to 40**). 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 during summer and winter and the animals observed during summer might be the same counted or observed during in winter. However, some populations of all the existing species at the four sites were estimated scientifically and are discussed later on in the chapter.

Table 36 – Mammals recorded from Keti Shah during summer and winter surveys

Sr. No.	Common Name	Summer survey	Winter survey	Total Animals
1	Asiatic jackal	12	4	16
2	Jungle cat	2	-	2
3	Bengal fox	1	-	1
4	Desert fox	1	-	1
5	Indian otter	-	11	11
6	Small Indian mongoose	7	1	8
7	Grey mongoose	3	-	3
8	Small Indian civet	1	-	1
9	Hog deer	2	3	5
10	Indian wild boar	4	14	18
11	Indus dolphin	3	13	16

Table 37 – Mammals recorded from Chotiari reservoir during summer and winter surveys

Sr. No.	Common Name	Summer survey	Winter survey	Total animals
1	Asiatic jackal	25	12	37
2	Caracal	3	-	3
3	Jungle cat	3	2	5
4	Fishing cat	2	1	3
5	Indian desert cat	2	-	2
6	Bengal fox	3	1	4
7	Desert fox	2	-	2
8	Indian otter	7	12	19
9	Small Indian mongoose	7	5	12
10	Grey mongoose	5	2	7

11	Hog deer	7	7	14
12	Indian wild boar	7	2	9
13	Chinkara	3	-	6
14	Feral donkey	90	-	90

Table 38 – Mammals recorded from Pai Forest during summer and winter surveys

Sr. No.	Common Name	Summer survey	Winter survey	Total population
1	Asiatic jackal	25	15	40
2	Jungle cat	2	1	3
3	Bengal fox	3	2	5
4	Small Indian mongoose	5	1	6
5	Grey mongoose	2	-	2
6	Small Indian civet	6	-	6
7	Hog deer	18	20	19
8	Indian wild boar	85	-	85

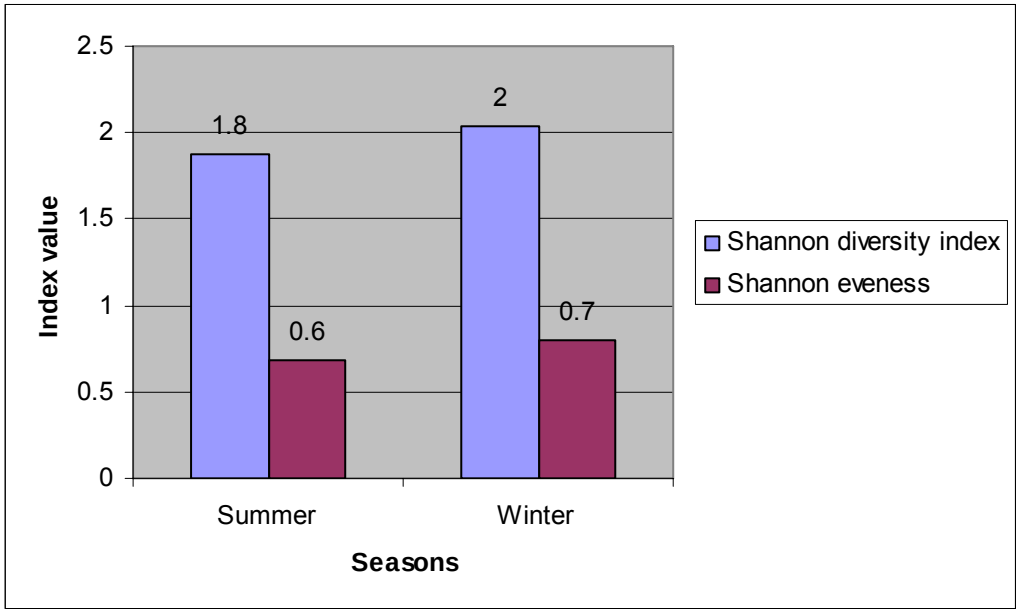
Table 39 - Mammals recorded from Keenjhar Lake during summer and winter surveys

Sr. No.	Common Name	Summer survey	Winter survey	Total Animals
1	Asiatic jackal	46	14	60
2	Jungle cat	2	4	6
3	Fishing cat	1	3	4
4	Bengal fox	1	-	1
5	Desert fox	1	-	1
6	Small Indian mongoose	4	2	6
7	Grey mongoose	2	-	2
8	Indian wild boar	15	-	15
9	Indian pangolin	1	1	2

Table 40 – Mammals recorded from Keti Bunder during summer and winter surveys

Sr. No.	Common Name	Summer survey	Winter survey	Total Animals
1	Asiatic jackal	13	4	17
2	Jungle cat	2	-	2
3	Fishing cat	1	-	1
4	Indian desert cat	1	-	1
5	Bengal fox	2	1	3
6	Desert fox	1	-	1
7	Small Indian mongoose	12	2	14
8	Grey mongoose	5	3	8
9	Small Indian civet	2	-	2
10	Indian wild boar	4	7	11
11	Bottle-nosed dolphin	-	2	2
12	Hump-backed dolphin	-	62	62
13	Finless porpoise	2	-	2
14	Indian pangolin	2	-	2

Figure 20 – 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.

4.1.7 Population Estimations

Populations of 14 different large mammals were estimated that included eight from Pai forest, four from Chotiari reservoir, three from Keenjhar one from Keti Bunder and two from Keti Shah. Estimated populations are given in the **Table 41** and **42**.

Table 41 – Estimated population of species found at the five sites

	Hog Deer	Indian Wild Boar	Indus dolphin	Small Indian civet	Desert fox	Asiatic jackal	Jungle cat
Keti Bunder	n/a	0	n/a	n/a	n/a	0	n/a
Keenjhar Lake	n/a	15	n/a	n/a	5	46	n/a
Chotiari Reservoir	7	n/a	n/a	n/a	6	n/a	n/a
Pai Forest	19	85	n/a	6	n/a	40	3
Keti Shah	n/a	n/a	13	n/a	n/a	n/a	n/a

Table 42 – Estimated population of species found at the five sites

	Bengal Fox	Small Indian Mongoose	Grey mongoose	Indian Otter	Chinkara	Hump-backed Dolphin
Keti Bunder	n/a	n/a	n/a	n/a	n/a	62
Keenjhar Lake	n/a	n/a	n/a	n/a	n/a	n/a
Chotiari Reservoir	n/a	n/a	n/a	12	5	n/a
Pai Forest	5	40	27	n/a	n/a	n/a
Keti Shah	n/a	n/a	n/a	11	n/a	n/a

4.1.8 Assessment of level of threats to mammals at different study sites

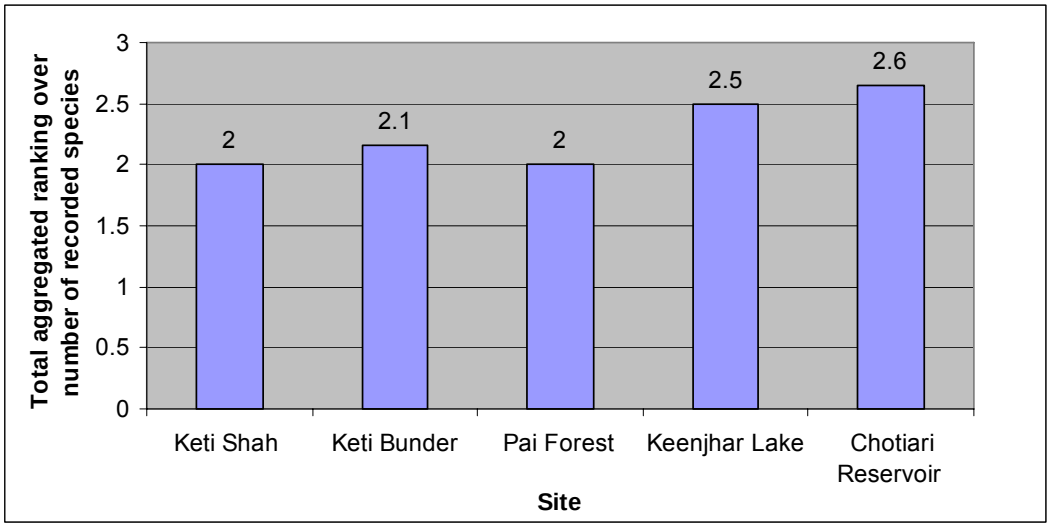
Various threats to different mammals were identified at five different study sites that include; habitat destruction, illegal hunting, poaching, live trapping, food competition, lack of awareness, law and order situation, weak enforcement of wildlife laws etc. Based on indirect and direct observations 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 Indus for All Programme sites.

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

Table 43 – Assessment of level of threats to mammals at different study sites

Sr. No.	Common Name	Keti Shah	Keti Bunder	Pai Forest	Keenjhar Lake	Chotiari Reservoir
1	Asiatic jackal	2	2	2	2	2
2	Caracal or Desert lynx		-	-	-	4
3	Jungle cat	2	2	2	4	3
4	Fishing cat	-	3	-	4	3
5	Indian desert cat	-	3	-	-	2
6	Bengal fox	2	3	2	2	3
7	Desert fox or Red fox	2	3	-	2	3
8	Indian otter	4	-	-	5	4
9	Small Indian mongoose	1	1	1	1	1
10	Grey mongoose	1	1	1	1	1
11	Small Indian civet	2	3	2	-	-
12	Hog deer	4	-	4	-	3
13	Indian wild boar	1	1	2	2	2
14	Chinkara	-	-	-	-	2
15	Feral donkey	-	-	-	-	4
16	Indus dolphin	1	-	-	-	-
17	Bottle-nosed dolphin	-	1	-	-	-
18	Hump-backed dolphin	-	1	-	-	-
19	Finless porpoise	-	1	-	-	-
20	Indian pangolin	-	3	-	2	-

Figure 21 – Aggregated threat ranking adjusted against number of species recorded from each site

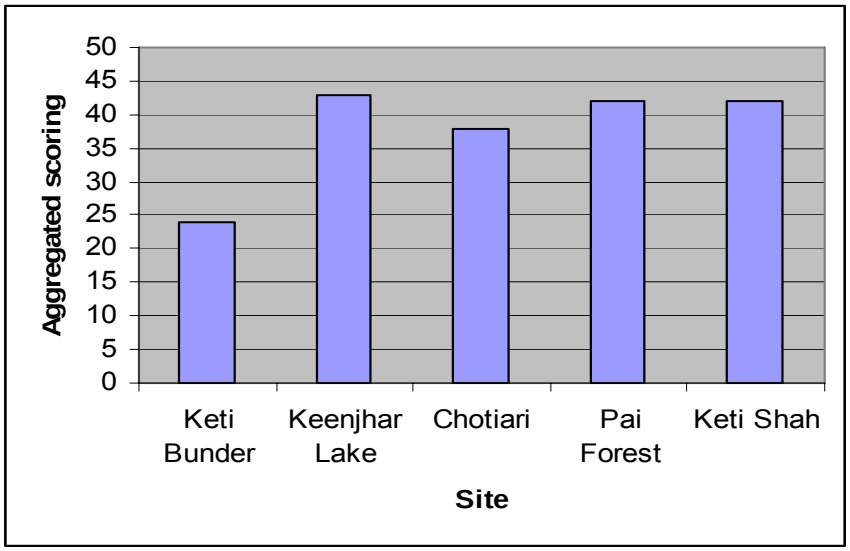


Chotiari Reservoir and Keenjhar Lake had the highest averaged disturbance factor against the species that were recorded there. Though this is an arbitrary scoring it does give an indication over the overall threat to large mammals at each site. Looking at general issues over the sites, Table 41 lists all the potential threats and attributes scores to them (ranging from 1 to 5, see legend below **Table 44**) across the sites. **Figure 22** gives the aggregated score for all sites.

Table 44 – Threats ranking for large mammals at sites

S. No.	Nature of Threats	Keti Bunder	Keenjhar Lake	Chotiari reservoir	Pai Forest	Keti Shah
1	Food competition with livestock	1	1	1	4	1
2	Disease transmission from livestock	1	1	2	2	1
3	Habitat removal / degradation	1	3	2	4	3
4	Wood cutting	2	1	1	4	4
5	Lack of awareness	3	3	3	3	3
6	Killing of problem species / pests	2	4	2	2	2
7	Poisoning of animals	1	1	2	1	1
8	Hunting Pressure	1	5	5	3	3
9	Hunting with dogs	0	2	1	4	1
10	Use of fire arms	0	5	4	4	3
11	Live trapping	1	3	3	3	4
12	Dominance of feral dogs	5	4	3	3	2
13	Water pollution	1	1	1	0	0
14	Presence of fish farms	0	4	3	0	0
15	Entanglement of cetaceans in fishing gears	1	0	0	0	0
16	Weak enforcement of wildlife laws	3	5	5	5	5
17	Law and order situation	0	0	0	0	5
18	Natural threats	1	0	0	0	4
	Total score	24	43	38	42	42
1= low, 2 = medium, 3 = average, 4= significant, 5 = high						

Figure 22 – Aggregated score for disturbance factors across sites



Most of the sites have similar ranking with Keenjhar Lake on top followed by Pai Forest, Keti Shah and Chotiari Reservoir. Surprisingly Keti Bunder has significantly less disturbance than other sites, perhaps due to relatively less human population.

4.2 Small mammals

4.2.1 Species recorded

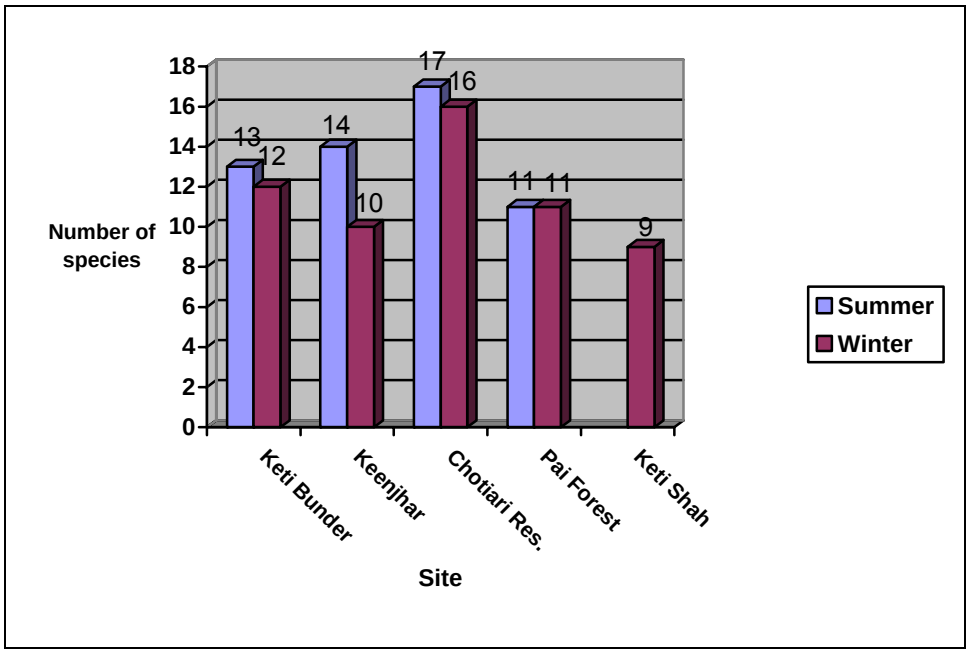
A total of 23 small mammal species were observed or collected from the five sites of the Indus for All Programme, 15 from Keti Bunder, 17 from Keenjhar, 19 from Chotiari reservoir, 14 from Pai forest and 9 from Keti Shah riverine forest. Most of these species were recorded in summer. The table below gives an account of species found at each site.

Table 45 – Total species recorded at five sites over summer and winter

	English Name	Scientific Name	Keti Bunder		Keenjhar		Chotiari reservoir		Pai		Keti Shah	
			S	W	S	W	S	W	S	W	S	W
1	Cairo spiny mouse	*Acomys cahirnus*	-	+	+	-	-	-	-	-	-	-
2	Leaf-nosed bat	*Asellia tridens*	-	-	+	-	-	+	-	-	-	-
3	Sindh Rice Rat	*Bandicota bengalensis*	+	+	+	+	+	+	+	+	-	+
4	Palm Squirrel	*Funambulus pennantii*	+	+	+	+	+	+	+	+	-	+
5	Baluchistan Gerbil	*Gerbilus nanus*	-	-	-	+	+	+	-	-	-	-
6	Indian bush rat	*Golunda ellioti*	+	+	-	-	-	-	+	-	-	-
7	Long-eared Hedgehog	*Hemiechinus collaris*	+	-	+	-	+	+	+	+	-	-
8	Indian crested porcupine	*Hystrix indica*	+	+	+	+	+	+	+	+	-	+
9	Desert hare	*Lepus nigricolis*	+	+	+	-	+	+	+	+	-	-
10	Indian Desert Jird	*Meriones hurrianae*	-	-	-	+	+	+	-	-	-	-
11	Sand coloured rat	*Millardia gleadwi*	-	+	-	-	+	-	-	+	-	-
12	Soft-furred field rat	*Millardia meltada*	-	-	-	-	+	+	-	+	-	-
13	Little Indian field-mouse	*Mus booduga*	-	-	-	-	+	+	-	-	-	-
14	House mouse	*Mus musculus*	+	-	+	-	+	+	+	+	-	+
15	Grey spiny mouse	*Mus saxicola*	-	-	+	+	-	-	-	-	-	-
16	Short-tailed rat	*Nesokia indica*	-	-	-	-	-	+	-	-	-	-
17	Indian Hedgehog	*Paraechinus micropus*	+	-	+	+	+	+	-	+	-	+
18	Kuhls' bat	*Pipistrellus kuhlii*	+	+	+	+	+	-	+	-	-	-
19	Common Rat	*Rattus rattus*	+	+	+	+	+	+	+	+	-	+
20	Large mouse tailed bat	*Rhinopoma microphyllum*	+	+	+	-		-	-	-	-	+
21	Common yellow-bellied bat	*Scotophilus heather*	-	-	-	-	+	-	+	-	-	-
22	House shrew	*Suncus murinus*	+	+	-	-	+	+	-		-	+
23	Indian Gerbil	*Tatera indica*	+	+	+	+	+	+	+	+	-	+

Figure 23 below shows the number of small mammal species recorded at each site over summer and winter. Chotiari Reservoir has the highest level of diversity followed by Keenjhar, Keti Bunder and then Pai Forest.

Figure 23 – Comparison of number of small mammal species over summer and winter



4.2.2 Similarity index over sites and seasons

Figures 24 and **25** shows the similarity over sites. There is similarity over Keti Bunder, Keenjhar Lake, Pai Forest and Keti Shah during winter and very little with Chotiari Reservoir. This phenomenon is common over most of the terrestrial studies indicating that Chotiari Reservoir has some inherent quality that makes it outstanding in terms of biodiversity.

Figure 24 – Similarity index over five programme site during summer

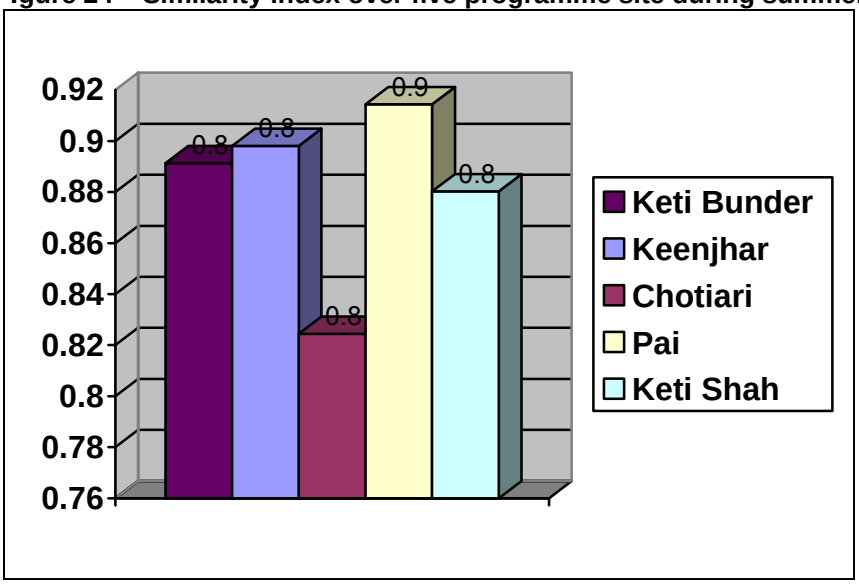
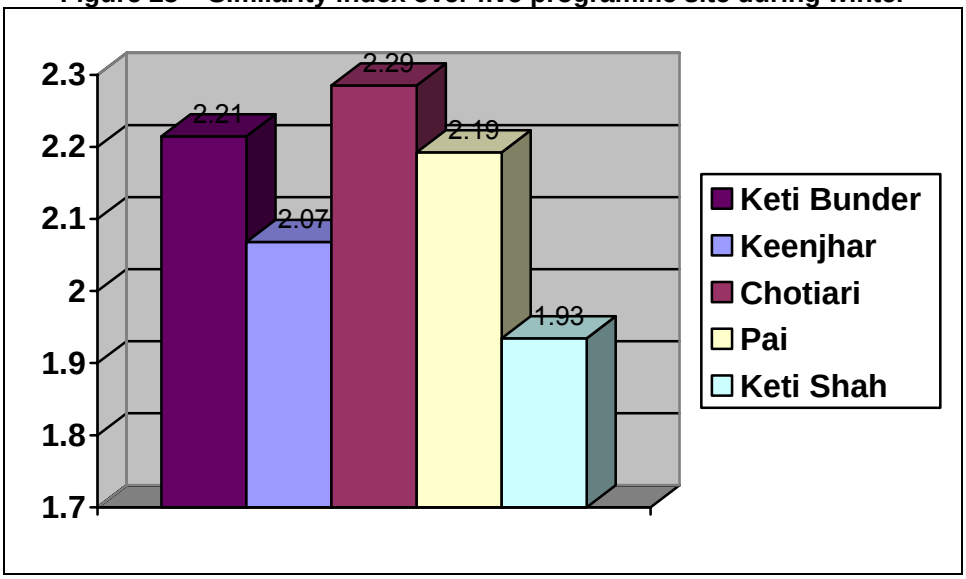


Figure 25 – Similarity index over five programme site during winter



4.2.3 Feeding habits

The feeding habits of small mammals varied over sites though with no particular trend over the sites. Given the diversity of habitats over sites this is to be expected. Over the season there was some variation of feeding habits, probably due to change in food availability since many small mammal species adapt to constantly changing situations. **Figures 26 and 27** give details of the percentage of species in each site against the main feeding habits.

Figure 26 – Percentage of species recorded for each site over feeding habit

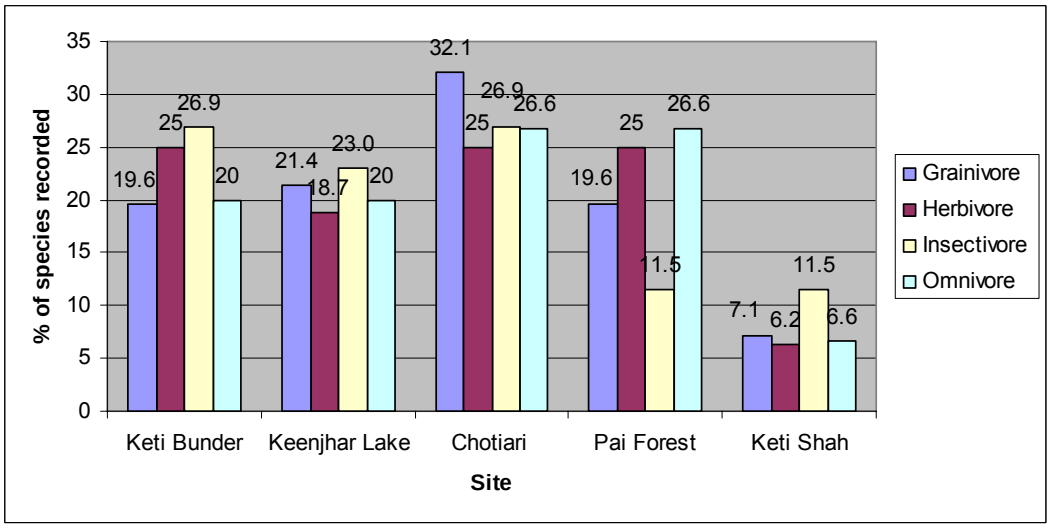
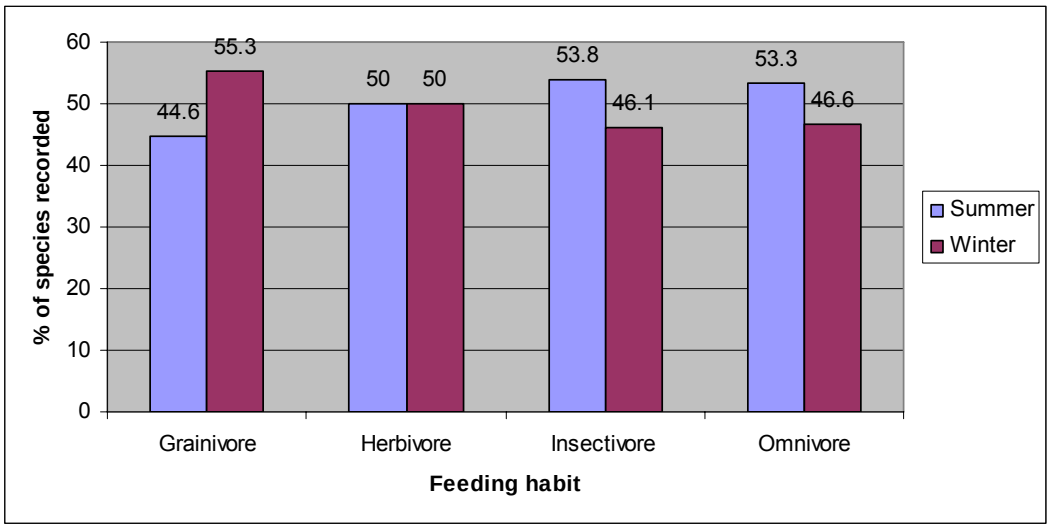


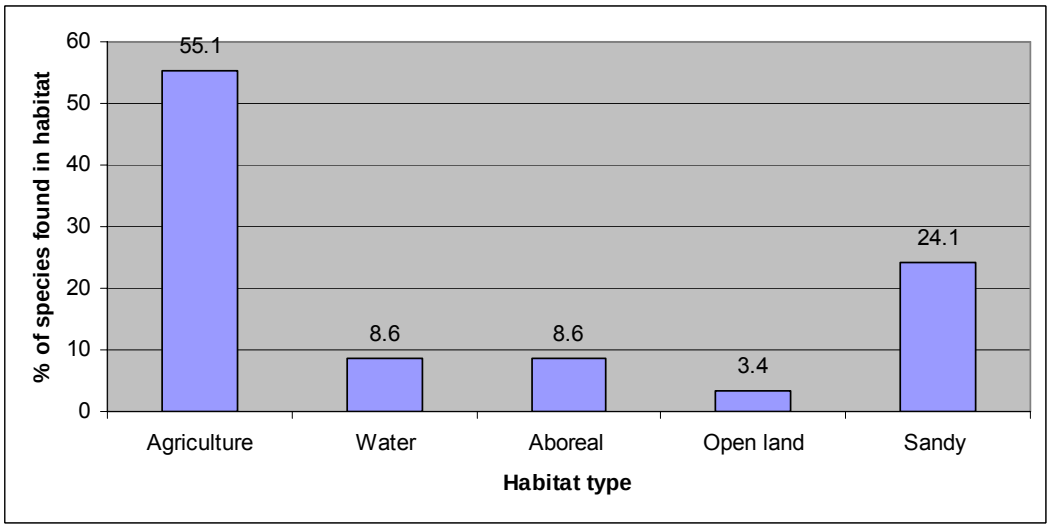
Figure 27 – Percentage of species recorded over season and against feeding habits



4.2.4 Habitat

Over the fives sites agriculture habitat supported the most species with more than 50% of all records being taken from agriculture habitats followed by sandy habitats (23%). The remaining water, tree and open habitats mad up the outstanding 27%. **Figure 28** shows the percentage of species found in each habitat. This result indicates that agriculture land plays an important role in maintaining the ecosystem, despite it being a man-made ecosystem. The fact that open land supported very few small mammal species also suggests that some minimum vegetative cover is required to support a diversity of small mammals.

Figure 28 – Number of species observed according the habitat



4.2.5 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 except in Keti Bunder where species if Less Concern were more dominant that Common species and vice versa in Keenjhar Lake where

Common species were more dominant. **Figure's 29 and 30** show the results over site and season.

Figure 29 – Percentage of species recorded across sites against status categories

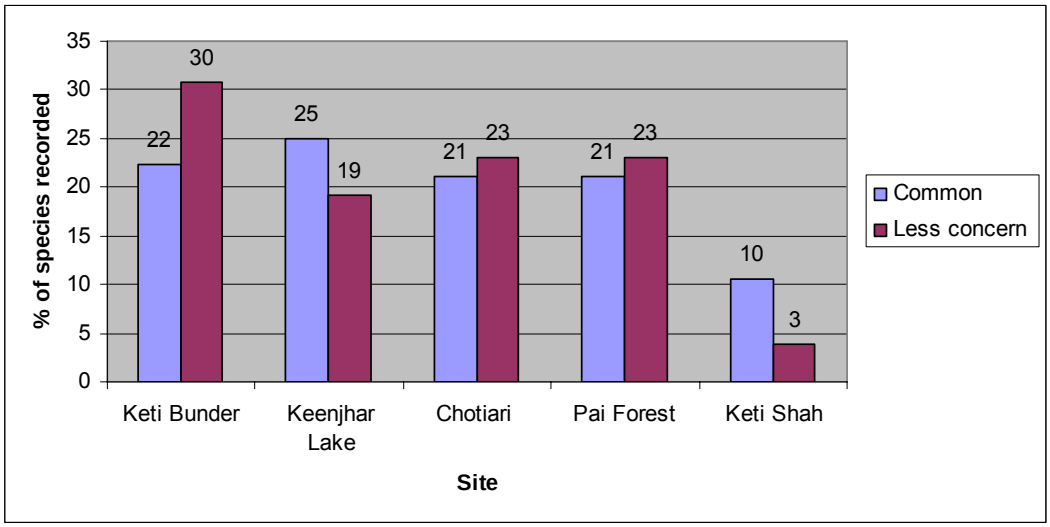
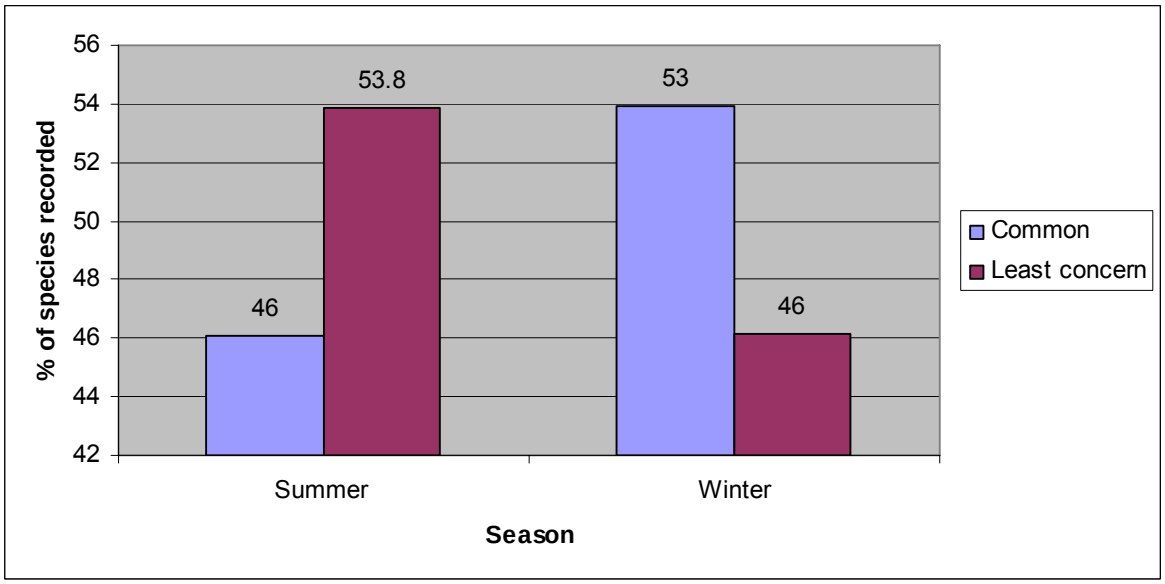


Figure 30 – Percentage of species recorded across season against status categories



4.3 Reptiles and amphibians

4.3.1 Summary

During summer and pre-winter surveys, 3251 amphibians and reptiles were either observed or collected. A total of 65 species are distributed among the entire IFAP sites of which 47 herpetiles were either observed or collected. The remaining 18 (represented by blue rows) species reported by the earlier workers or the local inhabitants could not be confirmed during the surveys. It does not imply that these species are not present in the study sites. There is likelihood that these species might be observed during future ecological assessment of herpetiles.

Out of all the programme sites, Chotiari Reservoir is the most productive herpetofauna associated habitat with the highest richness (31) and Margalef diversity index of 4.1277, Keti Bunder representing the second highest richness (27) and diversity with Margalef index of 3.823, Keenjhar Lake being at third place with richness (23) and Margalef diversity index of 3.506. The Pai forest and Keti Shah are least diverse of all the five programme sites with Margalef diversity indices of 3.237 and 2.845 respectively. The herpetofauna of Keti Shah is less diverse as compared to other sites due to the consistent seasonal inundation, which renders very little favorable conditions for the support of herpeto-fauna. The Pai forest, on the other hand, is so severely depleted in terms of human disturbances and wood-cutting that the herpetiles are unable to support their lives in an imbalanced ecosystem.

Some systematic records of amphibians and reptiles have been reported from the Indus for All Programme sites by Minton (1966), Mertens (1969) and Muhammad Shareef Khan (2003, 2005). Comprehensive biological assessment with reference to amphibians and reptiles has however never been conducted. The preliminary baseline studies made by Hafeez-ur-Rehman (2007) report 23 species of amphibians and reptiles from Keti Bunder, 31 from Keenjhar Lake, 35 from Chotiari Reservoir and 23 species from Pai Forest. These were reported, based on collection, observation or as a result of interviews with local people or reported by the earlier authors. The detailed assessment studies conducted in June 2007 enlist and document 27 species of amphibians and reptiles from Keti Bunder, 23 species from Keenjhar Lake, 31 species from Chotiari Reservoir, 18 species from Pai forest and 16 species from Keti Shah. The number of species collected and observed during the fieldwork carried out in June and November, 2007 in programme sites, is lower than the total number expected in the area but was not unexpected for the following reasons: 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 unfavorable conditions. The amphibians and reptiles are mostly nocturnal species and require night surveys. Some of the sites were difficult to approach at night and the nocturnal survey was only possible in limited areas. Amphibian and reptilian activity is also restricted to a specific time of the day and specific season of the year. If the presence of the team in the area did not correspond with the appropriate activity time and specific habitat of the species the possibility of sighting the species became minimal despite the other environmental conditions being suitable, and the species being present. 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 baseline studies need much more time to effectively prepare herpeto-faunal inventory of the area.

4.3.2 Species recorded

During the present studies, the author has been able to document and enlist 27 species of amphibians and reptiles from Keti Bunder, 23 species from Keenjhar Lake, 31 species from Chotiari Reservoir, 18 species from Pai forest and 16 species from Keti Shah. The quantitative assessment and comparison of species diversity and evenness through Shannon-weaver diversity index of these sites in terms of amphibians and reptilian diversity is given in the **Table 46.**

Table 46 – Amphibian and reptilian diversity among sites (Figures are number of individuals observed/collected)

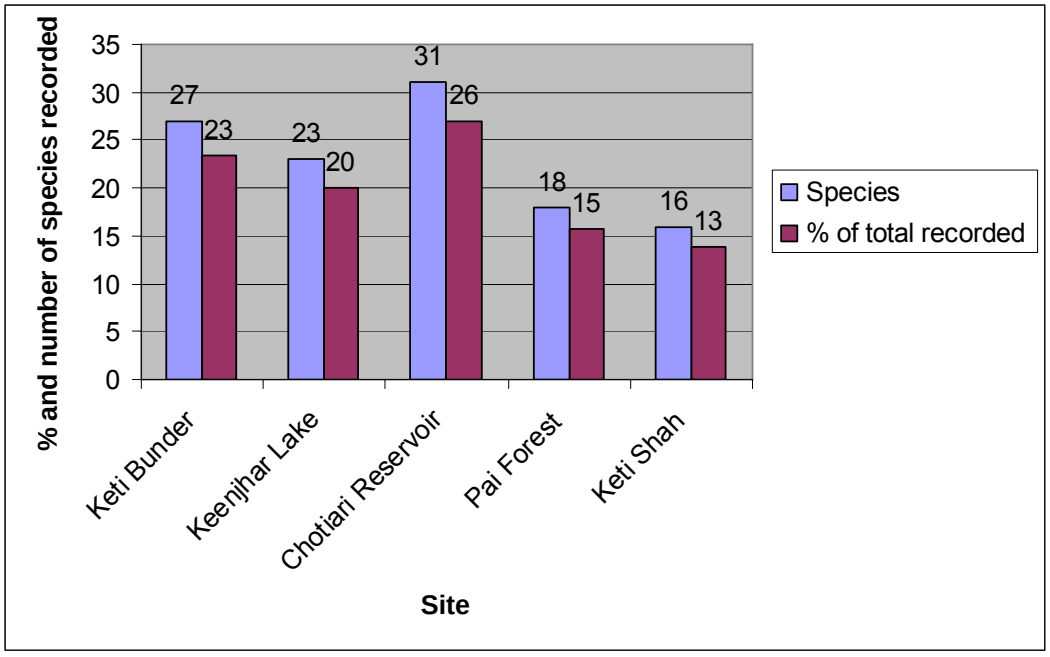
S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
1	*Bufo stomaticus*	387	117	74	139	42	15
2	*Euphlyctis c. cyanophlyctis*	138	39	32	47	20	0
3	*Hoplobatrachus tigerinus*	126	31	50	33	08	04
4	*Kachuga smithi*	128	0	0	66	0	62
5	*Kachuga tecta*	33	0	0	14	0	19
6	*Geoclemys hamiltonii*	30	0	0	30	0	0
7	*Hardella thurjii*	03	0	0	0	0	03
8	*Aspideretes gangeticus*	15	0	02	08	0	05
9	*Aspideretes hurum*	0	0	0	0	0	0
10	*Chitra indica*	0	0	0	0	0	0
11	*Lissemys punctata andersoni*	28	14	04	04	06	0
12	*Geochelone elagans*	0	0	0	0	0	0
13	*Crocodylus palustris*	100	0	0	100	0	0
14	*Calotes v. versicolor*	220	170	28	12	05	05
15	*Trapelus agilis pakistanensis*	58	0	49	09	0	0
16	*Trapelus megalonyx*	19	0	12	07	0	0
17	*Trapelus rubrigularis*	08	0	08	0	0	0
18	*Eublepharis macularius*	30	0	13	13	04	0
19	*Crossobamon orientalis*	141	0	0	141	0	0
20	*Cyrtopodion scaber*	66	25	25	12	04	0
21	*Hemidactylus brookii*	28	14	0	0	06	08
22	*Hemidactylus flaviviridis*	338	158	70	42	26	42
23	*Hemidactylus leschenaultii*	07	0	0	0	07	0
24	*Cyrtopodion k. kachhense*	07	0	07	0	0	0

S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
25	*Acanthodactylus cantoris*	260	06	24	230	0	0
26	*Eremias cholistanica*	15	0	0	15	0	0
27	*Mesalina watsonana*	04	0	0	04	0	0
28	*Ophisops jerdonii*	17	04	04	0	09	0
29	*Novoeumeces blythianus*	0	0	0	0	0	0
30	*Eutropis macularia*	0	0	0	0	0	0
31	*Eutropis dissimilis*	53	41	0	0	06	06
32	*Ophiomorus tridactylus*	271	0	0	271	0	0
33	*Ophiomorus raithmai*	0	0	0	0	0	0
34	*Eurylepis t. taeniolatus*	03	0	0	0	03	0
35	*Uromastyx hardwickii*	58	18	22	11	07	0
36	*Varanus bengalensis*	223	73	48	65	24	13
37	*Varanus griseus koniecznyi*	0	0	0	0	0	0
38	*Leptotyphlops macrorhynchus*	0	0	0	0	0	0
39	*Ramphotyphlops braminus*	0	0	0	0	0	0
40	*Eryx johnii*	24	08	08	08	0	0
41	*Eryx conicus*	11	0	01	04	03	03
42	*Python molurus*	0	0	0	0	0	0
43	*Amphiesma stolatum*	0	0	0	0	0	0
44	*Boiga trigonata*	0	0	0	0	0	0
45	*Lycodon s. striatus*	03	03	0	0	0	0
46	*Lycodon travancoricus*	0	0	0	0	0	0
47	*Lytorhynchus paradoxus*	0	0	0	0	0	0
48	*Oligodon a. arnensis*	01	01	0	0	0	0
49	*Platyceps r. rhodorachis*	0	0	0	0	0	0
50	*Platyceps v. indusai*	04	0	0	04	0	0
51	*Platyceps v. ventromaculatus*	12	10	0	0	02	0
52	*Psammophis c. condanarus*	0	0	0	0	0	0
53	*Psamophis l. leithii*	03	03	0	0	0	0
54	*Psamophis s. schokari*	0	0	0	0	0	0
55	*Ptyas m. mucosus*	34	09	13	09	0	03
56	*Spalerosophis arenarius*	0	0	0	0	0	0
57	*Spalerosophis atriceps*	08	04	04	0	0	0

S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
58	*Xenochrophis p. piscator*	21	06	11	0	0	04
59	*Xenochrophis c. cerasogaster*	02	0	0	02	0	0
60	*Naja n. naja*	23	16	0	06	0	01
61	*Bungarus c. caeruleus*	06	01	0	03	0	02
62	*Daboia r. russelii*	11	07	0	04	0	0
63	*Echis carinatus sochureki*	269	116	22	122	09	0
64	*Hydrophis caerulescens*	03	03	0	0	0	0
65	*Praescutata viperina*	02	02	0	0	0	0
	Total Number (number of individuals collected)	3251	899	531	1435	191	195

Rows shaded in light-blue and species reported in literature/ or reported by local inhabitants

Figure 31 – 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 summer and winter season data.

The results in **Table 47** show that Chotiari Reservoir has the highest species account, flowed by Keti Bunder, Keenjhar Lake, Pai Forest and then Keti Shah. However the evenness analysis shows that Chotiari Reservoir has the lowest evenness value, suggesting that the area is undergoing complex ecological

changes that may be natural or may be manmade e.g. flooding of habitats. Migration and hibernation can also affect reptile and amphibian species.

Table 47 – Species richness and diversity index for reptile and amphibian species recorded from Keenjhar Lake

S.no	Type of index	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
1	Richness (number of species)	27	23	31	18	16
2	Evenness	0.4526	0.6787	0.4563	0.6948	0.5376
3	Shannon Index	2.503	2.748	2.649	2.526	2.152
4	Margalef Index	3.823	3.506	4.127	3.237	2.845

Figure 32 – Evenness of reptile and amphibian species across sites

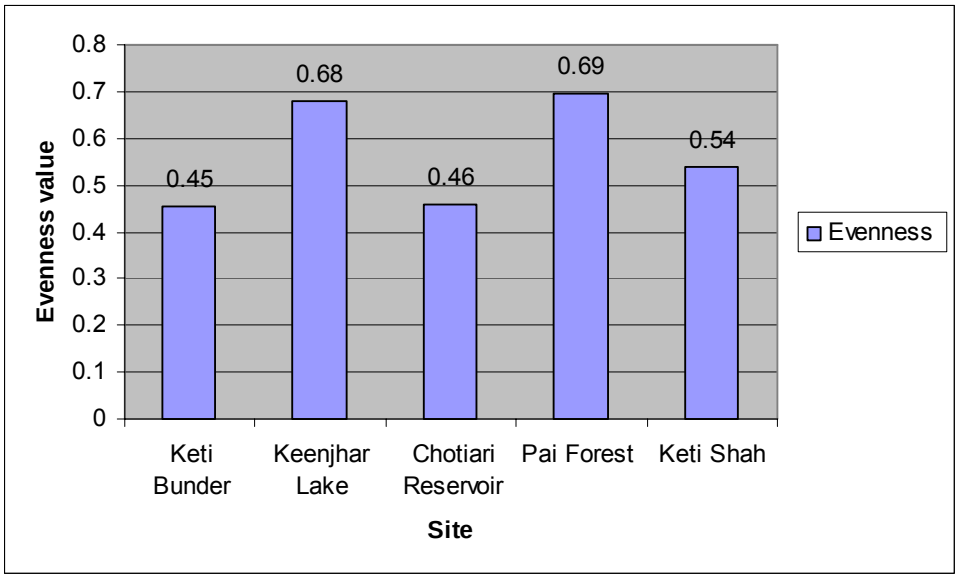
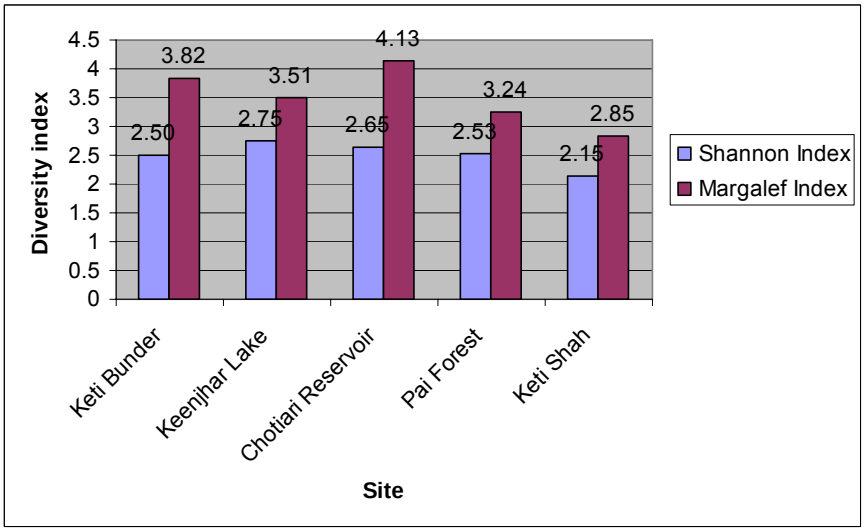


Figure 33 – Shannon and Margalef index for reptile and amphibian species for all sites



In the Margalef index Chotiari Reservoir shows the highest level of diversity whereas the Shanno index gives Keenjhar Lake as the highest. The former does not take into evenness so may be biased by the difference in animal counts. Overall Keti Shah has the lowest diversity in both analysis followed by Pai Forest. Reasons for the difference can be complex and need investigation to establish what is driving the diversity at each site.

4.4 Avi-fauna

4.4.1 Summary

4.4.1.1 Keti Bunder

The main habitats in Keti Bunder are coastal areas, creeks, agriculture and fruit farms, and riverine and estuarine area (Karo Chhan). A total of 68 species of birds were recorded during the summer surveys. Out of these 68 species recorded 22 were water birds, 6 birds of prey, and 25 passerines along with pigeons, doves, mynas, kingfishers, parakeets, cuckoos, bee-eaters and woodpeckers. Blue rock-pigeon, Common myna and Common-babbler were quite common Grey and Black Partridges and Rain quails are they key species at this site.

Along with the above mentioned birds 3 species were over summering bird's viz. Curlew Eurasian Redshank and Osprey along with the summer breeding visitor, Pied Crested Cuckoo. The majority of the birds were found to in forest areas, cultivated land and orchards. The main creek area comprises of Hajamro, Chann, Khobar and Bhoori creeks.

A total of 91 species of birds were recorded in the winter surveys 50 species were resident, 32 winter visitors, 7 were irregular year-round visitors and 2 passage migrants. 2 species were rare and 6 species were scarce. The important species recorded were; Painted Stork, Black-headed Ibis, Common quail, Black-bellied tern, Rufous-fronted Prinia, Paradise flycatcher and Rosy pastor.

4.4.1.2 Keenjhar Lake

The main habitats for birds in Keenjhar Lake are marshes, agriculture areas, fallow land, stony areas and desert habitat. There are agriculture fields in the north, east and western sides with an embankment on the southern side. Between the bund and the National Highway, there are marshy areas with villages around the lake. In the north is the town of Jhimpeer. There is a stony area and desert habitat the astern and western Side.

A total of 57 species of birds were recorded in summer out of which 20 were water birds, three raptors, twenty five passerines and twelve other including Pigeons, Doves, Cuckoos, Bee-eaters etc. Two early migrants' viz. barn swallow and green sandpiper were recorded. The most common Bird species of Keenjhar Lake were Little grebe, Little cormorant, Pond heron, Little egret, Pond heron, Red-wattled lapwing, Blue rock-pigeon, Collared dove, Little brown-dove Little Green Bee-eater, Bank myna and Streaked-weaver. Grey partridge, Purple heron and Chestnut-bellied sandgrouse are the key species.

During the winter surveys, the main lake associated marshes, agricultural fields, vicinity of villages, fish farm areas, grass field, bunds of the lake and another wetland viz Jhol Dhand were surveyed. A total of 98 species of birds were recorded. Out of which 51 were resident, 42 winter visitors 03 were irregular year-round visitors and two passage migrants. Most of the birds were found on or near the wetland habitats. A pair of Pallas's Fishing Eagle was found nesting on

Eucalyptus near Jakhro fish form. Among the threatened species, the Black-bellied tern which is a near threatened species was recorded. On the nearby wetland called Jhol Dhand, some important species such as greater flamingo, Pallid Harrier, Common Kestrel, Imperial Eagle, Steppe Eagle and Chestnut bellied Sandgrouse were recorded.

4.4.1.3 Chotiari Reservoir

Chotiari Reservoir is located in Sanghar District, it occupies an area of about 18,000 ha and the reservoir exhibits of terrestrial and aquatic ecosystems. The aquatic features of the reservoir area comprise diversity of small and large size (1-200 ha) fresh and brackish water lakes. These lakes are a source of subsistence and commercial fisheries for the local people and habitat for crocodiles, otters, fresh water turtles and feeding and nesting grounds for variety of resident and migratory birds. It has diverse habitat for birds, which include lakes, swamps/marshes/reed beds having somewhat dense vegetation cover, irrigations canals, riverine forest, cultivates land and desert area. The area provides suitable habitat for a wide variety of birds. As many as 109 species of birds have been recorded from the area (Ghalib et al 1999). There are certain species of birds of particular importance viz. Marbled Teal, Jerdon's/Sind Babbler, Pallas's Fishing Eagle, White-backed Vulture, Saker Falcon, Watercock, Wood Sandpiper, Knot, Ruff, Painted Snipe and Cliff Swallow.

The main area of the Chotiari reservoir is the wetland where there are marshes beside the embankment. There are agricultural fields in the northern and western side. The southern and the eastern sides consist of desert habitat. A total of 80 birds were recorded in the summer survey. Four summer breeding visitors viz. Water cock, Red Turtle Dove, Blue-cheeked, Bee-eater and Pied Crested Cuckoo were recorded. Two over summering birds viz. White-tailed Plover, Greenshank were also recorded. A total of thirty passerines, twenty-five water birds, four raptors and eleven others including pigeons, doves, cuckoos owls, nightjars, kingfishers, bee-eaters and rollers were observed. Plain Sand Martin and Barn Swallow were also quite common at the time. Grey and Black Partridge, Watercock, Chestnut-bellied Sandgrouse, Lesser Golden backed Woodpecker are also key species found at the site.

The main habitats in the area are wetland and associated marshes, desert habitat and agriculture areas. During the winter surveys, the nearby dhands were also surveyed such as Dogriyoon, Naughno, Panihal, Sanghriaro, Rarr and Kharor dhands. A total of seventy-two species of birds were recorded. Out of which 34 were resident, 34 were winter visitors, three passage migrants and one rare vagrant Purple Heron (two) and Red-crested Pochard (one) and Greater White fronted Goose (one) were recorded. Nesting of Pallas's Fishing Eagle was also recorded.

4.4.1.4 Pai Forest

Pai forest has forest and agriculture areas as which are home to various habitats of birds. The total number of bird species recorded was 56. Out of these, 6 were water birds, 3 raptors, 29 passerines, and 18 others including pigeons, doves, parakeets, kingfishers, cuckoos, rollers, owlets, nightjars, bee-eater etc. the most common species were: Little Brown Dove, Little Green Bee-eater and Bank Myna Two over summering birds viz. Baillon's Crake and Green Sandpiper and two summer breeding visitors viz. Pied Crested Cuckoo and Red Turtle Dove were recorded. Grey Partridge, Common Green Pigeon, Crested Honey Buzzard,

Shikra, Sind Pied Woodpecker and Lesser Golden Woodpecker are the key species.

Keti Shah is a riverine forest areas. 54 Species of Birds were recorded in the summer surveys, water birds, 3 raptors, 25 passerines and 14 other having partridges, Pigeons, Doves, Parakeets, Cuckoos, Kingfishers, Bee-eaters and Rollers etc. The common species were, Pond Heron, Black kite, Red-wattled lapwing, House swift, Little Green bee-eater, Plain sand-martin and Blue rock-pigeon. The key species are Grey and Black partridge. A summer breeding visitor viz. Small Indian pratincole, and one early migrant viz. Common swallow and one passage migrant viz. Rosy starling were recorded. A total of 92 species of birds was recorded in the winter surveys, out of which 58 species were resident 30 species were winter visitors, 1 species was year round visitor, 2 species were year round visitors.

4.4.2 Species recorded

The total number of bird species recorded on each site (inclusive of summer and winter season) is shown below in **Table 48.**

Table 48 – Total number of bird species recorded at each site

S. No.	Total No. of Species recorded on Each Site	No. of Species
1.	Chotiari reservoir Wetland Complex	113
2.	Keenjhar Lake	111
3.	Keti Bunder	108
4.	Pai Forest	81
5.	Keti Shah	79

The total number of birds recorded from all the 5 sites is 181 species. A total of 117 species of birds were recorded in summer and 158 species in winter.

Table 49 – List of bird species recorded from each site

	Common Name	Keenjhar		Keti		Chotiari reservoir		Pai forest		Keti Shah	
		S	W	S	W	S	W	S	W	S	W
1	Ashy crowned finch-lark	+	-	-	-	+	+	+	-	-	-
2	Asian Paradise flycatcher	-	-	-	+	-	-	-	-	-	-
3	Ballion's crake	-	-	-	-	-	-	+	-	-	-
4	Bank Myna	+	+	+	+	+	+	-	+	-	+
5	Barn owl	-	-	-	-	+	-	-	-	-	-
6	Baya weaver	-	-	-	-	-	-	-	-	-	+
7	Bay-Backed Shrike	+	+	-	-	+	+	+	-	-	+
8	Black bellied Tern	-	+	-	-	-	-	-	-	-	
9	Black Bittern	+	-	+	-	+	-	-	-	-	+
10	Black Drongo	+	+	+	-	+	+	+	+	-	+
11	black headed ibis	-	-	-	+	-	-	-		-	-
12	Black Kite	-	+	+	+	-	-	-	+	+	+
13	Black Partridge	-	-	+	+	+	-	-	-	+	+
14	Black Redstart	-	-	-	-	-	+	-	+	-	-
15	Black Shouldered Kite	+	+	+	-	+	+	-	+	-	-
16	Black winged Stilt	+	+	+	+	+	+	-	+	-	+

17	Black-bellied Tern	+	-	-	-	-	-	-	-	-	+
18	Black-billed tern	-	-	-	+	-	-	-	-	-	-
19	Black-breasted Quail	-	-	+	-	-	-	-	-	-	-
20	Black-Crowned Night Heron	-	+	-	-	+	+	-	-	+	-
21	Black-headed Gull	-	+	-	+	-	+	-	-	-	-
22	Blue Rock Pigeon	+	+	+	+	+	-	+	+	-	+
23	Blue-cheeked Beeater	-	-	-	-	+	-	-		-	-
24	Blue-throat	-	+	-	+	-	+	-	+	-	-
25	Brahminy Kite	+	+	+	+	-	-	+	+	-	+
26	Brown-headed Gull	-	-		+	-	-	-	-	-	-
27	Caspian tern	-	-	+	-	-	-	-	-	+	-
28	Caspian tern	-	-	-	+	-	-	-	-	-	-
29	Cattle Egret	+	+	+	+	+	-	+	+	+	+
30	Cettis Warbler	-	+	-	-	-	+	-	-	-	-
31	Chestnut-bellied Sand grouse	+	-	-	-	+	-	-	-	-	-
32	Cinnamon bittern	-	-	-	-	+	-	-	-	-	-
33	Clamorous Reed Warbler	-	+	-	-	-	-	-	-	-	-
34	Collared Dove	+	-	+	-	+	+	+	-	-	+
35	Common Babbler	+	+	+	+	+	+	+	+	-	+
36	Common buzzard	-	-	-	-	-	+	-	-	+	-
37	Common Crow Pheasant	+	+	+	+	+	+	+	+	+	+
38	Common green-pigeon	-	-	-	-	-	-	+	-	-	-
39	Common Kestrel	-	+	-	-	-	-	-	-	-	-
40	Common Kingfisher	-	+	+	+	+	-	-	-	+	-
41	Common Koel	+	-	+	+	+	-	+	-	-	+
42	Common Moorhen	-	+	-	-	+	+	-	-	-	-
43	Common Myna	+	+	+	+	+	+	+	+	-	+
44	Common or Black Coot	-	+	-	+	-	+	-	-	-	-
45	Common pochard	-	-	-	-	-	+	-	-	-	-
46	Common quail	-	-	-	+	-	-	-	-	-	-
47	Common Redshank	-	-	+	+	-	+	-	+	+	-
48	Common sandpiper	-	-	-	-	-	-	-	+	+	-
49	Common Snipe	-	+	-	-	-	-	-	-	-	-
50	Common Starling	-	+	-	-	+	-	+	-	-	-
51	Common Teal	-	+	-	+	-	+	-	-	+	-
52	Common wood-shrike	-	-	+	-	-		-	+	-	-
53	Common/Barn Swallow	+	+	+	-	+	+	-	+	-	+
54	Crested honey buzzard	-	-	-	+	-	-	+	+	+	+
55	Crested Lark	+	+	+	+	+	+	+	+	-	+
56	Desert Lark	+	+	-	-	-	-	-	-	-	-
57	Desert Wheatear	-	+	-	-	-	+	-	-	-	-
58	Eastern Pied Wheatear	-	+	-	-	-	-	-	+	-	-
59	Egyptian vulture	-	-	-	-	-	-	-	-	+	-
60	Eurasian Chiffchaff	-	+	-	+	-	+	-	-	-	-

61	Eurasian Curlew	-	-	+	+	-	-	-	-	-	-
62	Eurasian Griffon Vulture	-	+	-	-	-	-	-	-	-	-
63	Eurasian oystercatcher	-	-	-	+	-	-	-	-	-	-
64	Eurasian sparrowhawk	-	-	-	-	-	-	-	+	-	-
65	Eurasian Widgeon	-	-	-	+	-	-	-	-	+	-
66	Gadwall	-	+	-	-	-	+	-	-	+	-
67	Glossy ibis	-	-	-	-	+	+	-	-	-	-
68	Graceful Prinia	-	-	+	-	+	-	+	-	-	-
69	Great Black Headed Gull	-	+	-	+	-	+	-	-	-	-
70	Great Cormorant	-	-	-	+	-	+	-	-	-	-
71	Great Grey Shrike	+	+	-		+	-	-	-	-	-
72	Great stone-curlew	-	-	-	+	-	-	-	-	-	-
73	Great White Egret	-	+	-	+	-	+	-	-	+	-
74	Great-crested tern	-	-	-	+	-	-	-	-	-	-
75	Greater Flamingo	-	-	-	+	-	-	-	-	-	-
76	Greater sand plover	-	-	-	+	-	-	-	-	-	-
77	Greater Spotted Eagle	-	+	-	-	-	-	-	-	+	-
78	Greater white-fronted goose	-	-	-	-	-	+	-	-	-	-
79	Green sandpiper	+	+	-	-	-	-	+	-	+	-
80	Greenshank	-	+	-	+	+	-	-	+	+	-
81	Grey Heron	-		+	+	+	+	-	-	+	+
82	Gull-billed Tern	-	+	+	+	+		-	-	-	-
83	Herring Gull	-	+	-	+	-	+	-	-	-	-
84	Heuglins Gull	-	-	-	+	-		-	-	-	-
85	Hoopoe	-	+	-	-	-	+	-	-	-	-
86	House Bunting	-	+	-	-	-	-	-	-	-	-
87	Indian Collared Dove	-	+	-	+	-	-	-	+	-	-
88	Indian great-horned owl	-	-	-	-	-	-	-	+	-	-
89	Indian Grey Partridge	+	+	+	+	+	-	+	+	-	+
90	Indian Grey Partridge	+	+	+	+	+	+	+		-	-
91	Indian house crow	+	+	+	+	+	+	+	+	+	+
92	Indian House Sparrow	+	+	+	+	+	+	+	+	-	+
93	Indian Pond Heron	+	+	+	+	+	+	+	+	+	+
94	Indian River Tern	+	+	+	+	+	+		+	+	+
95	Indian Robin	+	+	-	-	+	-	+	+	-	+
96	Indian Roller	-	+	-	+	+	-	+	+	-	+
97	Indian sand-lark	-	-	-	-	-	-	-	+	-	-
98	Indian Tree-Pie	+	+	+	+	+	+	+	+	-	+
99	Intermediate Egret	-	+	-	-	+	+	-	-	-	-
100	Isabelline Shrike	-	+	-	-	-	-	-	+	-	-
101	Jungle Babbler	-	+	+	+	+	-	+	+	-	+
102	Kentish plover	-	-	+	+	-	-	-	-	-	-
103	Large-pied wagtail	-	-	-	-	-	+	-	-	-	-
104	Lesser crested tern	-	-	+	+	-	-	-	-	-	-
105	Lesser golden-backed woodpecker	-	-	+	+	+	-	+	+	-	-
106	Lesser sand plover	-	-	+	+	-	-	-		-	-
107	Lesser Whitethroat	-	+	-	+	-	+	-	+	-	-
108	Little Brown Dove	+	+	+	+	+	+	+	+	+	+
109	Little Cormorant	+	+	+	-	+	+	-		-	+

110	Little Egret	+	+	+	+	+	+	-	+	+	+
111	Little Grebe/Dabchick	+	+			+	+	-		-	-
112	Little Green Bee-eater	+	+	+	+	+	-	+	+	-	+
113	Little Green Heron	-	-	-	-	-	-	-	-	-	-
114	Little Ringed Plover	-	+	-		-	-	-	-	-	-
115	Little Stint	-	+	-	+	-	+	-	+	-	-
116	Little Tern	+	+	+	+	+	-	-	-	-	-
117	Little/House Swift	+	-	-	-	-	-	-	-	+	+
118	Long-legged buzzard	-	-	-	+	-	+	-	-	-	-
119	Long-tailed shrike	-	-	-	-	+	-	+	+	-	-
120	Mallard	-	-	-	-	-	+	-	-	+	-
121	Marsh Harrier	-	+	-	+	-	+	-	-	+	-
122	Marsh Sandpiper	-	+	-	-	-	-	-	-	-	-
123	Northern Pintail	-	+	-	+	-	+	-	-	-	-
125	Oriental white-eye	-	-	-	+	-	-	-	-	-	-
126	Osprey	+	+	+	+	-	+	-	-	+	-
127	Paddy-field Pipit	+	+	+	-	+		+	+	-	-
128	Paddy-field Warbler	-	+	-	-	-	-	-	-	-	-
129	Painted stork	-	-	-	+	-	-	-	-	-	-
130	Pallas's Fishing Eagle	-	+	-	-	+	+	-	+	+	-
131	Pheasant-tailed Jacana	+	+	+	-	+		-		-	-
132	Pied Bush Chat	+	+	+	+	+	+	+	+	-	-
133	Pied Kingfisher	+	+	+	+	+	+	-	+	+	+
134	Pied-crested cuckoo	-	-	+	-	+	-	+	-	-	+
135	Plain leaf Warbler	-	+	-	-	-	-	-	-	-	-
136	Plain prinia	+	+	+	-	+	+	+	+	-	+
137	Plain Sand Martin	-	+	-	-	+	+		+	-	+
138	Purple gallinule	-	-	-	-	+	+	-	-	-	-
139	Purple Heron	+	+	-	-	+	+	-	-	+	-
140	Purple Sun Bird	+	+	+	+	+	+	+	+	-	+
141	Red turtle-dove	-	-	-	-	+	-	+		+	-
142	Red-crested pochard	-	-	-	-	-	+	-	-	-	-
143	Red-vented Bulbul	+	-	+	+	+	-	+	+	-	+
144	Red-wattled Lapwing	+	+	+	+	+	+	+	+	+	+
145	Rose-ringed Parakeet	-	+	+	+	+	-	+	+	-	+
146	Rosy pastor	-	-	-	+		-	-	-	-	+
147	Rufous-fronted Prinia	-	-	+	+	+	-	+	-	-	+
148	Shikra	-	-	+	+	+	-	+	+	+	-
149	Short-eared owl	-	-	-	+	-	-	-	-	-	-
150	Shoveller	-	+	-	-	-	+	-	-	+	-
151	Sind pied woodpecker	-	-	-	-	-	-	+	+	-	-
152	Sind sparrow	-	-	-	-	+	-	-	-	-	+
153	Singing bush-lark	-	-	+	-	-	-	-	-	-	-
154	Slender billed gull	-	-	-	+	-	-	-	-	-	-
155	Small Indian pratincole	-	-	-	-	-	-	-	-	+	+
156	Small minivet	-	-	-	-	-	-	+	-	-	-
157	Small skylark	+	-	+	+	+	-	+	-	-	-
158	Spotted Owlet	-	-	-	-	+	-	+	+	+	-
159	Spotted redshank	-	-	-	-	-	-	-	-	+	-
160	Steppe Eagle	-	+	-	-	-	-	-	-	-	-
161	Streaked Weaver	+	-	+	-	-	-	-	-	-	+
162	Striated Babbler	+	+	+	-	-	+	+	+	-	+

163	Syke's Nightjar	-	+	-	+	+	-	+		-	-
164	Tailor bird	-		+	+	-	-	+	+	-	-
165	Tufted Duck	-	+	-	-	-	+	-	-	+	-
166	Watercock	-	-	-	-	+	-	-	-	-	-
167	Western reef heron	-	-	+	+	-	-	-	-	-	-
168	Whimbrel	-	-	-	+	-	-	-	-	-	-
169	Whiskered Tern	+	+	+	+	-	+	-	-	-	-
170	White cheeked tern	-	-	+	-	-	-	-	-	-	-
171	White spoonbill	-	-	-	+	-	-	-	-	+	-
172	White Wagtail	-	+	-	+	-	-	-	+	-	-
173	White-breasted Kingfisher	+	-	-	-	+	-	-	-	-	+
174	White-breasted Water hen	+	+	-	+	+	+	+	-	-	-
175	White-browed Fantail flycatcher	-	+	-	+	-	-	+	-	-	-
176	White-browed wagtail	-	-	-	-	+	-	-	-	-	+
177	White-cheeked Bulbul	+	+	+	+	+	+	+	+	-	+
178	White-eyed buzzard	-	-	+	+	+	-	-	-	+	-
179	White-tailed Lapwing	-	+	-	-	+	+	-	-	+	+
180	White-throated Kingfisher	-	+	-	+	-	+	+	-	+	-
181	White-throated Munia	-	+	+	-	-	-	+	-	-	-
182	Wire-tailed Swallow	+	-	+	-	+	-	-	-	-	-
183	Wood Sandpiper	-	+	-	-	-	+	-	-	-	-
184	Yellow- bellied Prinia	+	-	-	-	-	-	-	+	-	-
185	Yellow Bittern	+	-	-	-	+	-	-	-	-	-
186	Yellow Wagtail	-	+	+	+	-	+	-	-	-	-
187	Yellow-fronted woodpecker	-	-	-	-	-	-	+	-	-	-
188	Yellow-throated Sparrow	+	-	-	-	+	-	+	+	-	-

4.4.3 Analysis of avifauna recorded

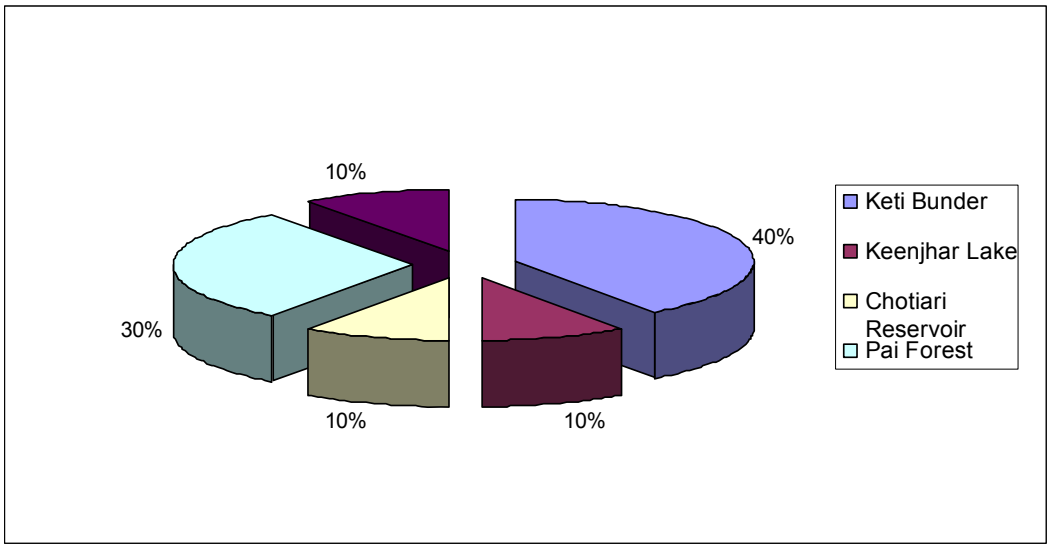
4.4.3.1 Summer survey

The following table **(Table 50)** shows the biodiversity index for each. This is also graphically shown in **Figure 34** as a pie-graph

Table 50 – Biodiversity index for sites surveyed during summer

	Site	Biodiversity index
1	Keti Bunder	0.04
2	Keenjhar Lake	0.01
3	Pai Forest	0.03
4	Chotiari Reservoir	0.01
5	Keti Shah	0.01

Figure 34 – Biodiversity Index of bird species during summer across all sites



It can be inferred the biodiversity runs (highest first) from Keti Bunder >Pai Forest >Keenjhar Lake> Chotiari Reservoir>Shah Belo.

Interestingly Chotiari Reservoir comes second to last whereas it would be expected to be on top like it does for mammals, reptiles and amphibians. Keti Bunder and Keenjhar Lake certainly have the potential to support a diverse variety of avifauna even though they are subjected to a high level of environmental degradation.

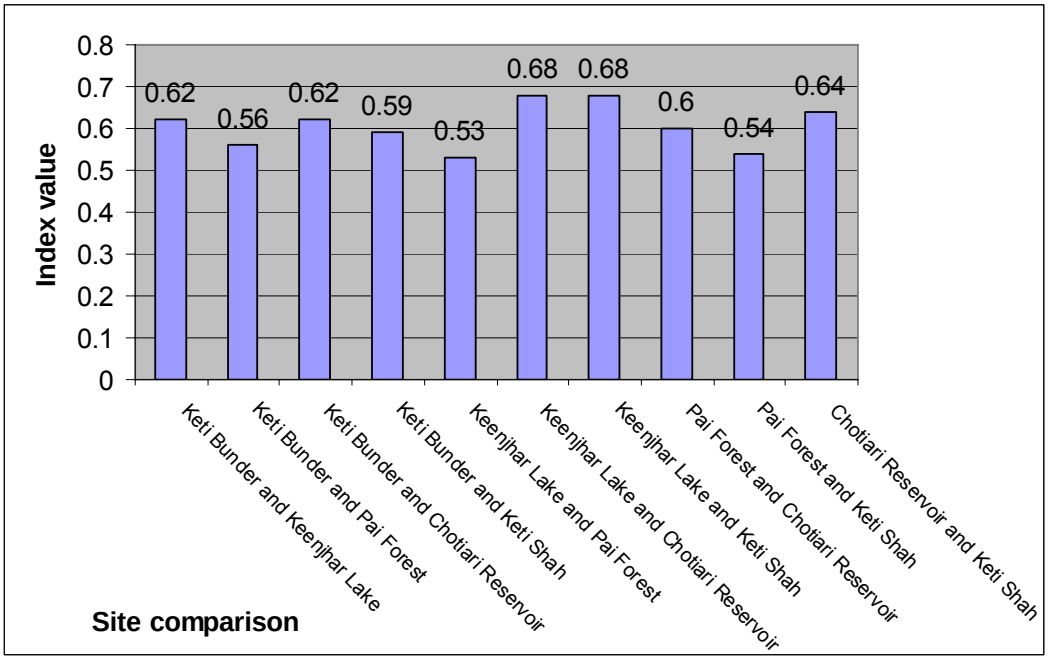
Looking at similarity index it can be inferred that the index value (highest first) runs as: Keenjhar lake: Chotiari Reservoir = Keenjhar Lake: Keti Shah>Chotiari Reservoir: Shah Belo>Keti Bunder: Chotiari Reservoir=Keti Bunder: Keenjhar lake>Pai Forest: Chotiari Reservoir>Keti Bunder: Keti Shah>Keti Bunder: Pai Forest>Keenjhar Lake: Pai Forest

Note: Species Similarity decreases from Keenjhar Lake: Chotiari Reservoir = Keenjhar lake: Shah Belo to Keenjhar Lake: Pai Forest

The list below gives the comparison index for each comparison. **Figure 35** gives a graphical outlay of the index.

- **Similarity Index**
  - Similarity Index Keti Bunder and Keenjhar Lake =0.62
  - Similarity Index Keti Bunder and Pai Forest =0.56
  - Similarity Index Keti Bunder and Chotiari Reservoir =0.62
  - Similarity Index Keti Bunder and Shah Belo =0.59
  - Similarity Index Keenjhar Lake and Pai Forest =0.53
  - Similarity Index Keenjhar Lake and Chotiari Reservoir =0.68
  - Similarity Index Keenjhar Lake and Shah Belo =0.68
  - Similarity Index Pai Forest and Chotiari Reservoir =0.60
  - Similarity Index Pai Forest and Shah Belo =0.54
  - Similarity Index Chotiari Reservoir and Shah Belo =0.64

Figure 35 – Similarity Index for birds recorded during summer across all sites

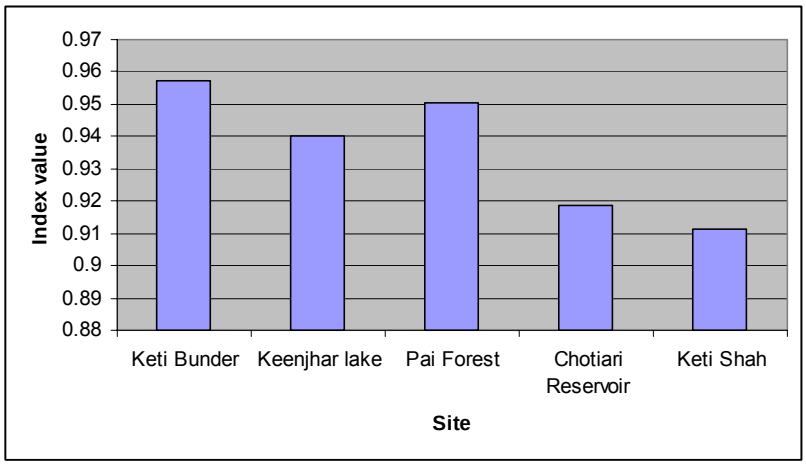


Finally coming to the biodiversity index, **Table 51** shows the indexes for each site and **Figure 36** gives a graphical portrayal of the same figures.

Table 51 - Simpson's Index from Keenjhar Lake in summer

S.no	Site name	Index
1	Keti Bunder	0.957305
2	Keenjhar lake	0.940157
3	Pai Forest	0.950601
4	Chotiari Reservoir	0.918462
5	Keti Shah	0.911427

Figure 36 – Simpson's diversity index for winter over all sites



It can be concluded that the index runs (highest firsts) as Keti Bunder >Pai Forest>Keenjhar lake >Chotiari Reservoir>Keti Shah. It is important to note that species similarity and species diversity increases from Keti Bunder to Keti Shah

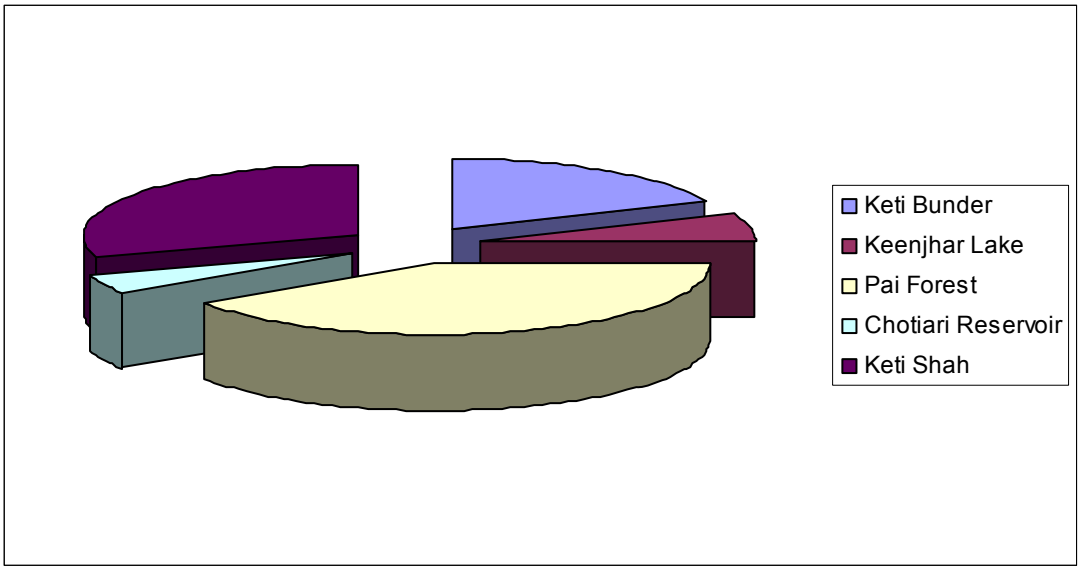
4.4.3.2 Winter surveys

Table 52 and **Figure 37** show the biodiversity index for winter results at Keenjhar Lake.

Table 52 – Biodiversity index for sites surveyed during winter

S.no	Site	Biodiversity index
1	Keti Bunder	0.02
2	Keenjhar Lake	0.007
3	Pai Forest	0.044
4	Chotiari Reservoir	0.005
5	Keti Shah	0.032

Figure 37 – Biodiversity Index of bird species during winter across all sites



It is evident from the lower values of biodiversity index in the above table and graph that the avifauna is not diverse. However, the sites can be arranged on a scale of species diversity in descending order as:

Pai Forest > Keti Shah > Keti Bunder> Keenjhar lake > Chotiari Reservoir

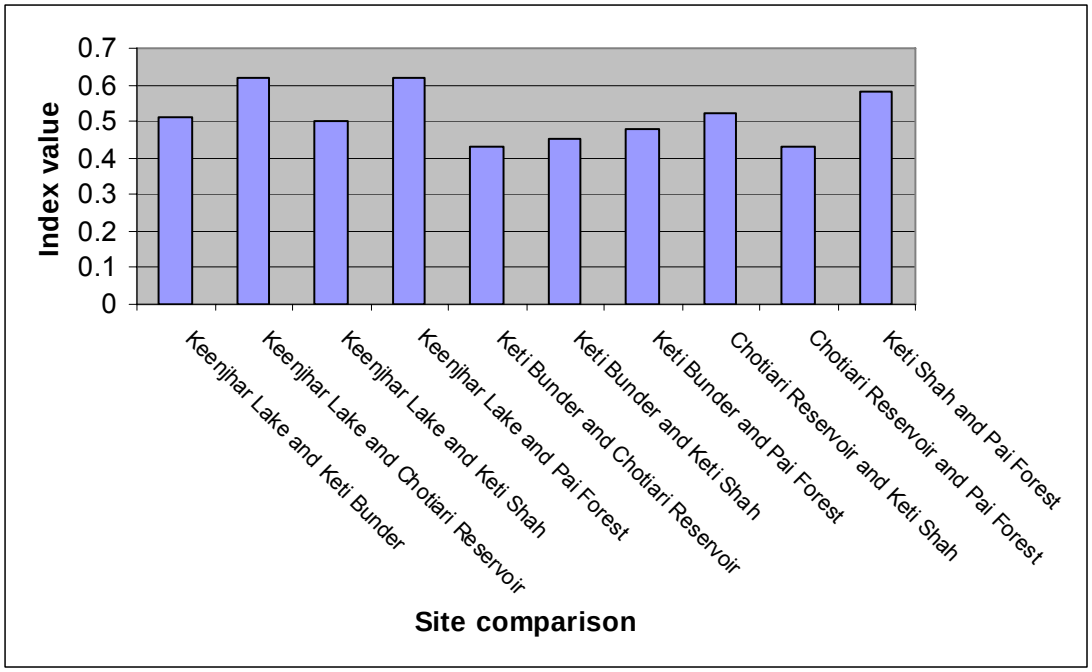
Again Pai Forest has the highest index followed by Keti Shah and then Keti Bunder. This is quite unusual since all of these sites are subjected to environmental degradation, especially Pai Forest. It would have been expected that the three wetlands, Chotiari Reservoir, Keti Bunder and Keenjhar Lake would have been on top, especially for avifauna.

Coming to the similarity index, the following list and **Figure 38** gives the similarity values across all sites

- **Similarity Index**
  - Similarity Index Keenjhar Lake and Keti Bunder = 0.51
  - Similarity Index Keenjhar Lake and Chotiari Reservoir = 0.62
  - Similarity Index Keenjhar Lake and Keti Shah = 0.5
  - Similarity Index Keenjhar Lake and Pai Forest = 0.62
  - Similarity Index Keti Bunder and Chotiari Reservoir = 0.43

- Similarity Index Keti Bunder and Keti Shah = 0.45
- Similarity Index Keti Bunder and Pai Forest = 0.48
- Similarity Index Chotiari Reservoir and Keti Shah = 0.52
- Similarity Index Chotiari Reservoir and Pai Forest = 0.43
- Similarity Index Keti Shah and Pai Forest = 0.58

Figure 38 – Similarity Index for birds recorded during winter across all sites



From above table and graph, higher values of similarity index show that Keenjhar lake-Chotiari Reservoir and Keenjhar-Pai Forest have much common species composition as compared to other pairs of sites. Pairs of sites can be arranged on a scale of similar species composition in descending order as:

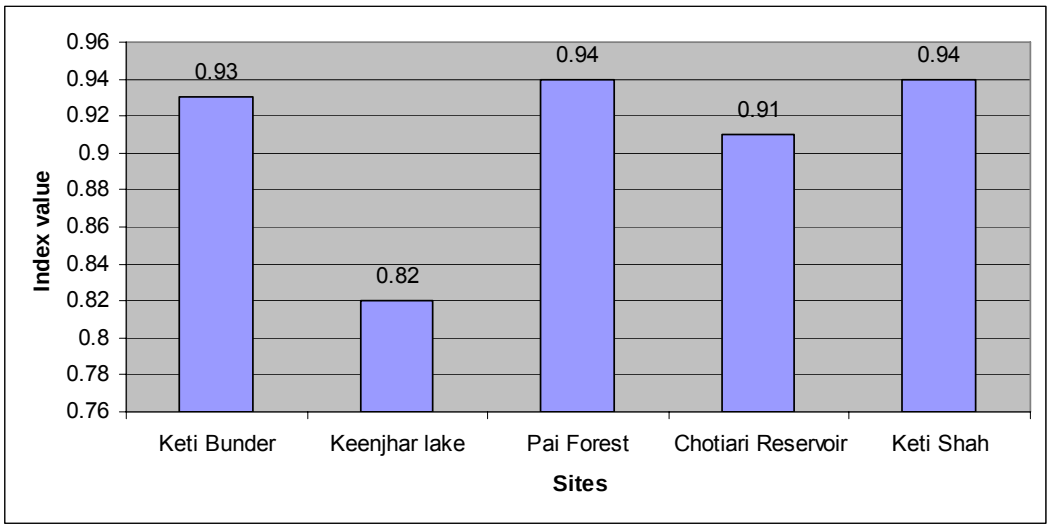
Keenjhar lake -Chotiari Wetlands Complex and Keenjhar- Pai Forest **>** Shah Belo-Pai Forest **>** Chotiari Wetlands Complex- Shah Belo > Keenjhar lake- Keti Bunder> Keenjhar lake- Shah Belo**>** Keti Bunder- Pai Forest> Keti Bunder- Shah Belo > Keti Bunder- Chotiari Wetlands Complex > Chotiari Wetlands Complex- Pai Forest

Finally coming to the diversity index for the sites, **Table 53** and **Figure 39** shows the Simpson's index for all the sites during winter.

Table 53 – Simpson's Index of all sites in winter

S.no	Site name	Index
1	Keti Bunder	0.93
2	Keenjhar lake	0.82
3	Pai Forest	0.94
4	Chotiari Reservoir	0.91
5	Keti Shah	0.94

Figure 39 – Simpson's index for all sites



The higher value of Simpson's index in above table and graph clearly spell out that bird species are evenly distributed at Keti Shah, Pai Forest and Keti Bunder. However, Keenjhar Lake's comparatively lower value implies dominance of fewer bird species at that lake. The sites can be arranged on a scale of species evenness in descending order as:

Shah Belo and Pai Forest > Keti Bunder > Chotiari Wetlands Complex > Keenjhar lake

4.4.3.3 Summer and winter

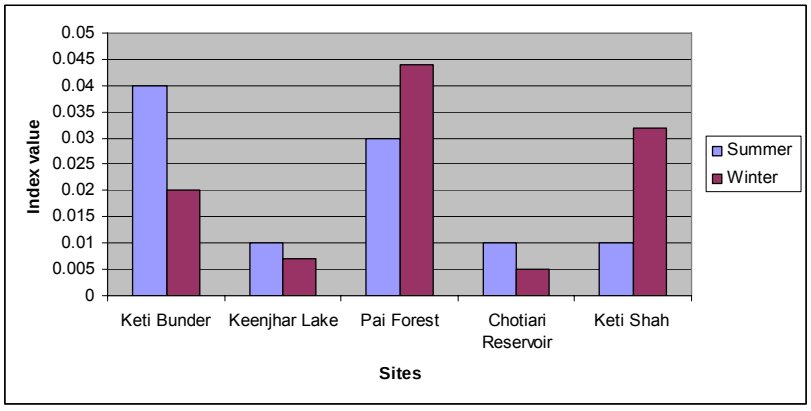
The following table and figures compare the biodiversity index, similarity and Simpson's index over the sites and over the season.

Table 54 and **Figure 40** show the biodiversity index over site and season

Table 54 – Biodiversity index over sites and over season

S.No	Site	Summer	Winter
1	Keti Bunder	0.04	0.02
2	Keenjhar Lake	0.01	0.007
3	Pai Forest	0.03	0.044
4	Chotiari Reservoir	0.01	0.005
5	Keti Shah	0.01	0.032

Figure 40 – Biodiversity indexes for all sites over summer and winter



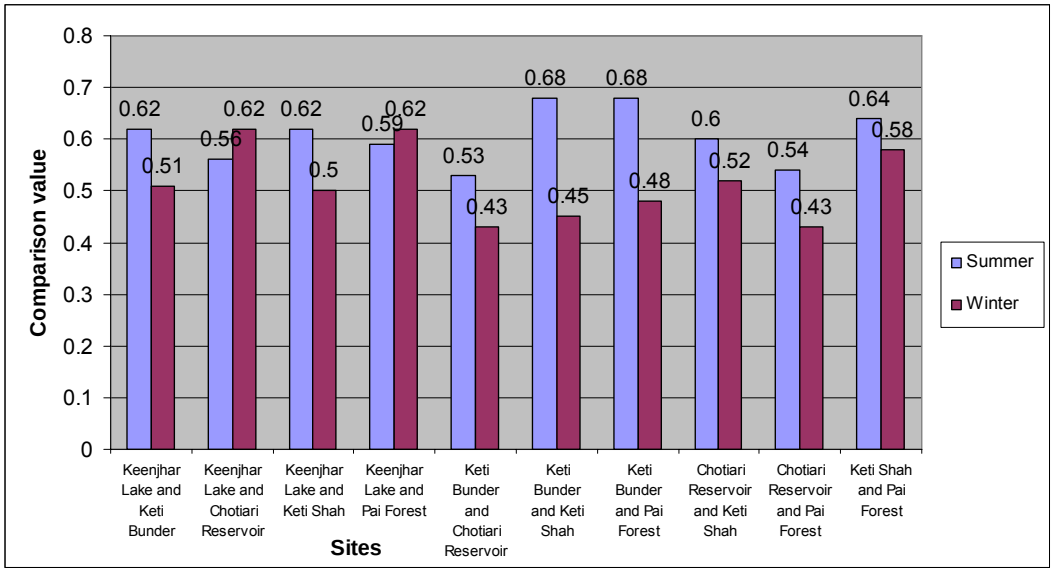
As can be seen in **Figure 40**, diversity is quite changeable over time and space. Pai Forest has the highest diversity in winter whereas Keti Bunder had the highest diversity in summer. Chotiari Reservoir is thought to be the most diverse site under the Indus for All Programme. However it is on par with Keenjhar Lake for both summer and winter. It is inferred that migration and anthropogenic factors such as hunting, trapping and habitat removal may be causing birds to avoid certain areas that may include our site areas.

Figure 41 shows the similarity between the sites.

	Summer	Winter
Similarity Index Keenjhar Lake and Keti Bunder	0.62	0.51
Similarity Index Keenjhar Lake and Chotiari Reservoir	0.56	0.62
Similarity Index Keenjhar Lake and Keti Shah	0.62	0.5
Similarity Index Keenjhar Lake and Pai Forest	0.59	0.62
Similarity Index Keti Bunder and Chotiari Reservoir	0.53	0.43
Similarity Index Keti Bunder and Keti Shah	0.68	0.45
Similarity Index Keti Bunder and Pai Forest	0.68	0.48
Similarity Index Chotiari Reservoir and Keti Shah	0.6	0.52
Similarity Index Chotiari Reservoir and Pai Forest	0.54	0.43
Similarity Index Keti Shah and Pai Forest	0.64	0.58

As with the diversity index, there is significant variation over winter and summer seasons. In summer there is more similarity with Keti Bunder – Keti Shah and Keti Bunder – Pai Forest whereas is winter the similarity lies in Keenjhar Lake – Pai Forest and Keenjhar Lake – Chotiari Reservoir. Again this indicates that the arrival (or departure) of migratory birds and/or differing levels of disturbance over the seasons is affecting the presence and absence of birds across the sites.

Figure 41 – Similarity index between sites and over season

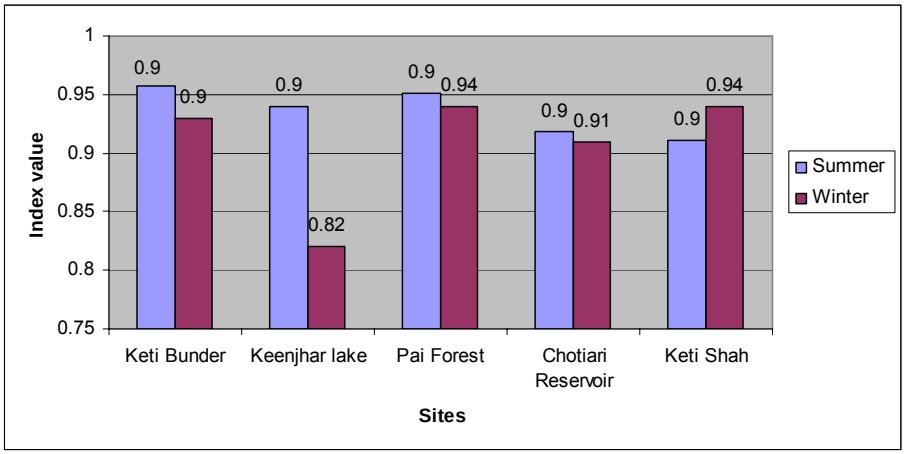


The following **Table 55** and **Figure 42** show the Simpson's index over sites and season.

Table 55 – Simpson's index over site and season

S.no	Site	Summer	Winter
1	Keti Bunder	0.95	0.93
2	Keenjhar lake	0.94	0.82
3	Pai Forest	0.95	0.94
4	Chotiari Reservoir	0.91	0.91
5	Keti Shah	0.91	0.94

Figure 42 – Simpson's index over sites and seasons



Apart from Keenjhar Lake, there is not much difference in the Simpson's index apart from slightly lower levels in winter. This does not necessary mean less species but since less evenness across the population of species.

Image 15 – Oriental reed-warbler at Keenjhar Lake

Image 16 – White wagtail at Keenjhar Lake

Image 17 – Indian Robin at Keti Shah

Image 18 – Striated babbler at Keti Shah

4.5 Phytoplankton

4.5.1 Summary

4.5.1.1 Keti Bunder

In Keti Bunder a total of 76 samples were collected and during the summer 26 algal/phytoplankton samples were collected out of which 39 algal species belonged to 30 genera of 6 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Dinophyta, Euglenophyta and Chlorophyta). During the winter surveys a total of 50 algal samples were collected in Keti Bunder; out of which 150 algal/phytoplankton species belonged to 65 genera of 8 phyla namely Cyanophyta, Volvocophyta, Dinophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta and Charophyta. The phyla Charophyta was not found in the summer survey.

4.5.1.2 Keenjhar Lake

In Keenjhar Lake a total of 65 algal/phytoplankton samples were collected during this period out of which 155 algal species belonging to 53 genera of 7 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Dinophyta, Chlorophyta, and Charophyta in the summer. In Chotiari reservoir a total of 85 algal/phytoplankton samples were collected during the summer months out of which 248 algal species belonging to 96 genera of 9 phyla (Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, and Charophyta.

More than 60 algal samples were collected from Keenjhar Lake, out of which 167 species belonging to 60 genera of 8 phyla namely Cyanophyta, Volvocophyta, Bacillariophyta, Dinophyta, Euglenophyta, Chrysophyta, Chlorophyta, and Charophyta were observed. The phyla Euglenophyta was not found in the summer survey.

4.5.1.3 Pai Forest

In Pai Forest a total of 67 Algal species were collected in the summer survey which belonged to 32 genera of 6 phyla Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Euglenophyta and Chlorophyta. A total of 33 (49.2%) species from 16 genera of phyla Cyanophyta, 10 (15%) species belongs to 7 genera of phyla Volvocophyta, 14 (20.8%) species belongs to 8 genera of phyla Bacillariophyta, 2 (3%) species belongs to 1 genus of phyla Xanthophyta, 4 (6%) species belongs to 2 genera of phyla Euglenophyta, 4 (6%) species belongs to 2 genera of phyla Chlorophyta.

4.5.1.4 Chotiari Reservoir

More than 100 samples were collected from Chotiari reservoir dam, out of these a total of 359 algal species belonging to 116 genera of 9 phyla Cyanophyta, Volvocophyta, Bacillariophyta, Chrysophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta and Charophyta, 80 aquatic plants and 32 fishes along with some physico-chemical parameters were recorded. The phyla Xanthophyta was not found in the summer survey. Twenty five algal samples were collected during the winter survey. Out of the 71 species belonging to 34 genera of 7 phyla e.g. Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta and Charophyta along with seventeen aquatic plants and some physico-chemical parameter were recorded, water is rich in primary productivity and plant production. The phyla Charophyta was not found in the summer survey.

4.5.2 Account of number of species recorded

All the samples from the four sites were of better quality during the winter surveys compared to the ones in summer (**see Figure 43 below**). This may be due to better water quality and lack of salinity which was observed in the summer months.

Figure 43 – summer and winter comparison of the number of species collected in the four sites

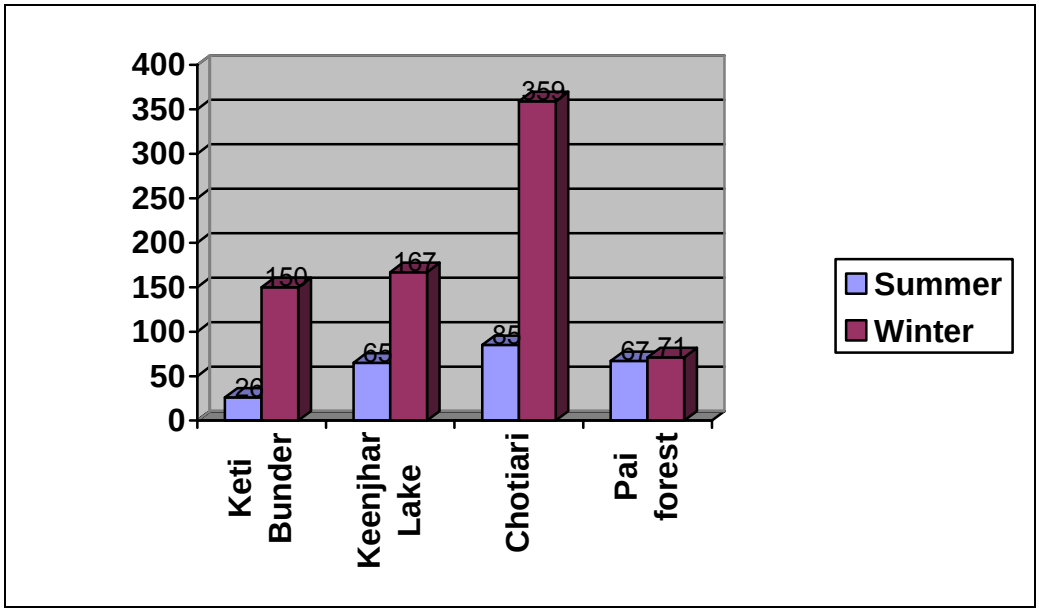


Table 56 – Comparison of phylum during the summer and winter survey in all four sites

S.no	Class	Keti Bunder		Keenjhar Lake		Chotiari reservoir		Pai Forest	
		Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
	Phylum								
1	Cyanophyta	✓	✓	✓	✓	✓	✓	✓	✓
2	Volvocophyta	✓	✓	✓	✓	✓	✓	✓	✓
3	Bacillariophyta	✓	✓	✓	✓	✓	✓	✓	✓
4	Xanthophyta	✓	✓	×	×	×	✓	✓	✓
5	Dinophyta	✓	✓	✓	✓	✓	✓	×	×
6	Euglenophyta	✓	✓	×	✓	✓	✓	✓	✓
7	Chlorophyta	✓	✓	✓	✓	✓	✓	✓	✓
8	Charophyta	×	✓	✓	✓	✓	✓	×	✓
9	Chrysophyta	×	×	✓	✓	✓	✓	×	×

4.6 Freshwater fisheries

4.6.1 Introductory note

Comparison of freshwater fisheries is only applicable to Keenjhar Lake and Chotiari Reservoir and therefore only appears in these reports. There is a separate report for Keti Bunder under marine fisheries.

4.6.2 Species account

A total of 55 species of fish were recorded from Keenjhar Lake and a total of 47 from Chotiari Reservoir. Both water bodies are freshwater and are fed by the River Indus, therefore similar if not exact species are expected from each site. **Table 57** below gives an account of the species present at each water body.

Table 57 – Freshwater fish species recorded from Keenjhar Lake and Chotiari Reservoir

S.no	Species	Keenjhar	Chotiari reservoir
1	*Ailia coila*	+	+
2	*Amblypharyngodon mola*	+	+
3	*Aspidoparia morar*	+	+
4	*Bagarius bagarius*	+	+
5	*Barilius vagra*	+	+
6	*Chanda nama*	+	+
7	*Channa marulia*	+	+
8	*Channa punctata*	+	+
9	*Chela cachius*	+	+
10	*Chitala chitala*	+	+
11	*Cirrhinus mrigala*	+	+
12	*Cirrhinus reba*	+	+
13	*Clupisoma garua*	+	+
14	*Clupisoma naziri*	+	-
15	*Colisa fasciata*	+	+
16	*Colisa lalia*	+	-
17	*Ctenopharyngodon idella*	+	-
18	*Cyprinus carpio*	+	+
19	*Esomus danricus*	+	+
20	*Gagata cenia*	-	+
21	*Eutropiichthys vacha*	+	-
22	*Gagata cenia*	+	-
23	*Gibelion catla*	+	+
24	*Glossogobius giuris*	+	+
25	*Gudusia chapra*	+	+
26	*Heteropneustes fossilis*	+	+
27	*Labeo calbasu*	+	+
28	*Labeo dero*	+	+
29	*Labeo dyocheilus pakistanicus*	+	+
30	*Labeo gonius*	+	+
31	*Labeo rohita*	+	+
32	*Hypophthalmichthys molitrix*	+	-
33	*Hypophthalmichthys nobilis*	+	-
34	*Mastacembelus armatus*	+	+
35	*Mystus bleekri*	+	+
36	*Mystus cavasius*	+	+
37	*Mystus vittatus*	+	-
38	*Nangra nangra*	+	-
39	*Notopterus notopterus*	+	+
40	*Ompok bimaculatus*	+	+
41	*Oreochromis mossambicus*	+	+
42	*Osteobrama cotio*	+	+
43	*Parambasis baculis*	+	+
44	*Parambasis ranga*	+	+
45	*Puntius chola*	+	+
46	*Puntius sophore*	+	+
47	*Puntius ticto*	+	+
48	*Rasbora daniconius*	+	+

49	*Rita rita*	+	+
50	*Salmophasia bacaila*	+	+
51	*Securicula gora*	+	+
52	*Sicamugil cascasia*	+	+
53	*Sperata sarwari*	+	+
54	*Systomus sarana*	+	+
55	*Wallago attu*	+	+
56	*Xenentodon cancila*	+	+

4.6.3 Status of species at each site

The status of each fish species was assessed both locally and nationally. **Figure 44** shows the number of species recorded in each category over both the sites. Since both sites had a similar number of species (Chotiari Reservoir has seven less species) the numbers are quite comparable. As can be seen, most species fall under the common or less common category with only a few species being very common or rare. Of course it would be unusual to find many species belonging to the rare or very common category.

Figure 44 - Number of species recorded across each local status category (summer)

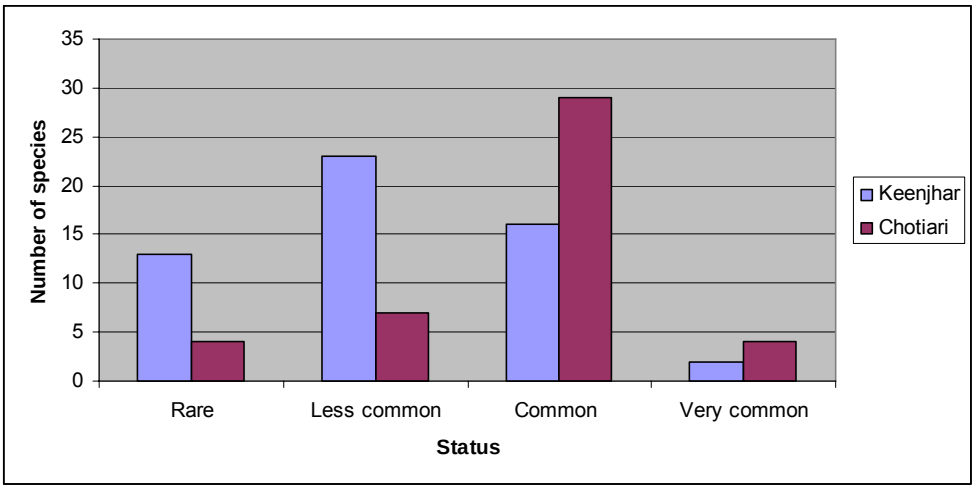


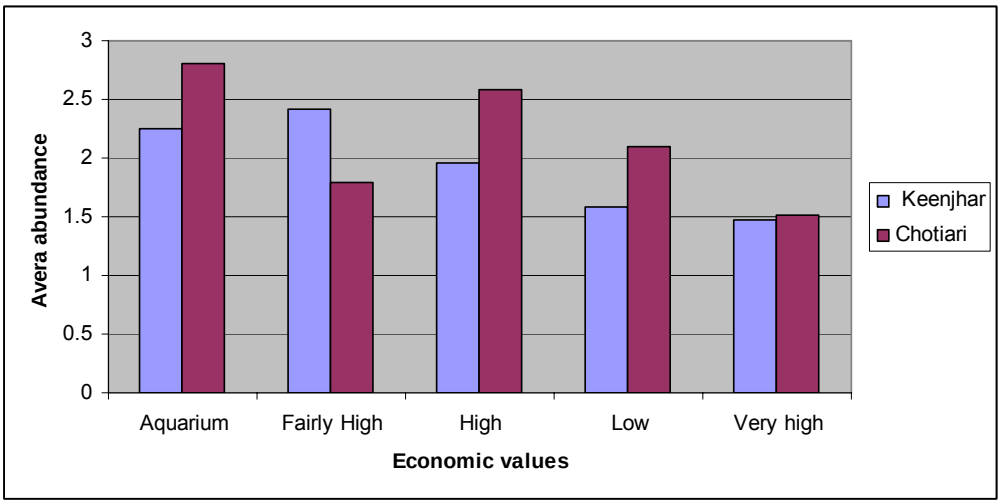
Figure 45 shows the status of fish species at national or country level. Most species fall into the category of common or less common and it is pertinent to note that no species were categorized as very common, indicating that either no fish species in the country has been classified under this category or that there are very few species that are very common, non of which are found in Keenjhar Lake or Chotiari Reservoir.

Figure 45 – Number of species recorded across each national or country status category (winter)

4.6.4 Economic values

The economic value for each species was identified and plotted against the average density (number of each fish species caught from 100). **Figure 46** shows the number of species in each category from the two freshwater sites. There was quite and even spread of species over the economic categories though most species had high or aquarium values. Species having very high value were the least common which may reflect that they are being targeted for extraction.

Figure 46 – Average abundance from each category over the two freshwater sites (Keenjhar Lake and Chotiari Reservoir)



4.7 Zooplankton

Note: there is no comparative study between the sites on zooplankton primarily because the results are so different between areas there is very little comparative data to use. Therefore the report on zooplankton has been kept to findings and discussion only

4.8 Physico-chemical properties of water

4.8.1 Summary of water quality

4.8.1.1 Drinking water

- **Keti Bunder**

  Two samples were collected from the Keti Bunder Town area. Sample KB- B1/A1is representing the surface drainage discharging in to Hajamro Creek near to Keti Bunder Town and sample KB-B2/A2 is representing the Keti Bunder Town waste water discharging in to Hajamro creek near Keti Bunder Town. Since these two effluents are falling into sea, therefore the National Environmental Quality Standards (NEQs) of Pakistan (*for the effluents disposal into sea)* are referred for comparison.

  It is worth mentioning that the time of sample collection (KB-B1) the water level in Hajamro creek at Keti Bunder Town and in the surface drain was high due to high tide which therefore flooded the surface drain. It is because of this the TDS and other related parameters such as EC, hardness, chlorides, sulphates were found higher than the sample collected from the same location after monsoon (KB-A1). This time the Hajamro Creek near to Keti Bunder Town and surface drain level were very low.

  The Waste water coming from Keti Bunder Town contains washing water (originally KB water /saline water) used for different purposes excluding the drinking water). The drinking water is an expensive commodity and comes in tankers. Since more water is used in non drinking house-hold activities, the waste water generated has high salinity/TDS and Ni content which is above the NEQs.

  Keti Bunder Creeks Area: The values of Keti Bunder water quality in creek areas were compared with the Coastal Water Quality Standards. The marine water quality values are those specified values which are considered safe for the marine life, fish, and mangrove growth. The results show that except for the phenol and nickel, the values of all parameters are well suited for all type of fish, prawn, and Palla fish grown in marine water. The cause of high nickel and phenol contamination could be attributed to the increasing level of pollution (municipal and industry waste) entering in to sea from Karachi.

  In Bhoori creek area people are using hand pump for drinking water, hence the sample was collected to find the drinking water quality parameters. The results of the tube well water show that the water quality is not very good, as it has the influence of the sea. The TDS and the salt concentration (calcium, magnesium chlorides and) were found exceeding the WHO drinking water quality standards. The nickel and phenol levels were also violating the WHO guidelines.

- **Keenjhar Lake**

  The total dissolved solid, TDS (or conductivity) is very important parameter along with pH in determining the water quality. The values of both in all samples fall within WHO acceptable range. The TDS below 500mg/l shows that the dissolved solids are on good side considering all of its uses.

  The turbidity (or TSS) is also within WHO standard of 5 NTU except at locations KL-A6 and A7 (Pre monsoon). These location points are near to K.B feeder. The K.B feeder receives water from Indus River at Kotri Barrage which contains high turbidity. The relatively higher levels were also noted at these locations during 1st sampling (before monsoon) period.

  The dissolved oxygen is found low (Less than 3.0mg/l) as the good quality surface water normally has dissolved oxygen as high as 9 mg/l (depending upon pH and temperature). The depletion of dissolved oxygen is an indicator of organic pollution causing BOD and COD. This was found more so when the water level and flow were low before monsoon period.

  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”. K.B feeder also carries the municipal effluents of Jamshoro and industrial effluents of Kotri site. The high levels of BOD and COD indicates that sufficient pollution is exerted in before monsoon period through K.B feeder water.

  The Phenol levels were very high due to use of washing and other Phenol substances by the people. The total hardness, sulphates, chlorides, calcium and magnesium were found in the acceptable range of WHO / other national and international guidelines.

  Toxic elements detected in the water consisted of chromium which is within the WHO guidelines, ld levels were found violating WHO standard, but this is not true before monsoon period. The Nickel levels were also found exceeding the WHO limit. The Cadmium levels, however were high at location Keenjhar Lake A6 and A7, having high turbidity of water entering from K.B Feeder.

- **Chotiari Reservoir**

  The drinking water quality is judged by comparing the results with the WHO drinking water quality Standards. The main reservoir data show that the water quality is fit for drinking according to the WHO standards. However, some parameters such as Cr, Ni and Phenol were a little excessive than the recommended guideline values. It seems that the Indus River water coming from upstream contains these contaminants because no other pollutant sources are seen. The TDS, pH and DO are within WHO guidelines. The COD and BOD values are slightly higher indicating some organic pollution coming from the upstream of the Indus River water. The CR-B8 is showing

high value of TDS, pH, Cl, and Mg which is attributed to seepage water.

The groundwater samples collected from the surrounding area of the reservoir have shown that the quality is very poor. All the assessed parameters are violating the WHO drinking water guidelines. The Arsenic has been particularly observed in the groundwater which shows higher value than the recommended WHO guidelines. It is noteworthy to mention that no significant change is observed in two data sets particularly for groundwater quality (Pre and post monsoon).

The lakes which are in the study area and are affected by the reservoir have no access of Indus River and that all are getting seepage water from the reservoir and rain water. The water quality confirms that it is not suitable for drinking and contains high TDS and salts of magnesium and calcium chlorides/sulphates. These lakes receive less rain water hence no major change is observed in water quality data sets of both before and after monsoon periods.

- **Pai Forest**

  The ground water of Pai Forest as sampled from two locations indicates that the water quality in most of the parameters is well within the WHO Drinking Water Quality Guidelines except the phenol and Arsenic. The Arsenic contamination in ground water has been an important issue; here it was also determined and found as high as 0.07 mg/l. The WHO Drinking Water guideline permits Arsenic up to 0.01 mg/l. Studies in other countries have shown that drinking water containing elevated levels of arsenic can cause the thickening and discoloration of the skin. Sometimes these changes can lead to skin cancer, which may be curable if discovered early. Numbness in the hands and feet and digestive problems such as stomach pain, nausea, vomiting, and diarrhea can also occur due to the elevated levels of arsenic.

  There is no industry or any other source which can be blamed for arsenic contamination. Previous studies suggest the geological formation of some area contain arsenic which gets drifted into the ground water.

- **Keti Shah**

  The ground water of Keti Shah as sampled from two locations indicates that the water quality in almost all parameters is well within the WHO Drinking Water quality guidelines. The two fresh water samples were also equally good with some little fluctuations. The Keti shah forest project area water was therefore good for all applications.

4.8.1.2 Agriculture

- **Keti Bunder**

  Most focus was in the creek areas which are devoid of agriculture land

- **Keenjhar Lake**

  The water quality of Keenjhar Lame is very good, considering the TDS (<500 mg/l, and pH(6.5-8.50) . The hardness, calcium, magnesium, chlorides and sulphates are as good as required for drinking water

quality. From this, it appears that None Degree of Restriction of Use is required for agriculture according to FAO Standards for agriculture crops. The water salinity (TDS) is well below 1000 mg/l, which is excellent as useable for all livestock and poultry as per FAO guidelines.

- **Chotiari Reservoir**

  The water quality of the reservoir is very good, considering the TDS (<500 mg/l, and pH (6.5-8.50). According to FAO Standards for agriculture crops, it appears that None Degree of Restriction of Use is applicable for agriculture crops, as it receives regular fresh water from the Nara Canal through Raunto Canal. The water salinity (TDS) of the reservoir is well below 1000 mg/l, which is excellent for all livestock and poultry as per FAO guidelines. The Bakar lake water is satisfactory for the use of livestock and poultry, however, the other two lakes: Dongrion and Patherio water is unfit for livestock and poultry. The groundwater is also unfit for agriculture and poultry but can be used for livestock. It is also noticed that there is no significant change in most of the parameters before and after monsoon period.

- **Pai Forest**

  The TDS of Pai Forest groundwater is slightly higher than the recommended value of FAO (450 mg/l) for the crops. The forest trees normally have more tolerance level then the crops. Therefore, this water quality can be considered as an acceptable standard for the forest. The pH value is also in the acceptable range (6.5-8.5). The water can be considered for Non Degree of Restriction of Use. The ground water salinity (TDS) is well below 1000 mg/l, which is excellent as useable for all livestock and poultry as per FAO guidelines.

- **Keti Shah**

  The TDS of Keti Shah Forest groundwater and surface water is excellent and lower than the recommended value of FAO (<450 mg/l) for the crops. The forest trees normally have more tolerance level than the crops. Therefore, this water quality can be considered good for the forest. The pH value is also in the FAO acceptable range (6.5-8.5). From this, it appears that this water can be considered for Non Degree of Restriction of Use. The ground water and surface water salinity (TDS) is well below 1000 mg/l, which is excellent as useable for all livestock and poultry as per FAO guidelines.

4.8.1.3 Fisheries

- **Keti Bunder**

  Water quality parameters were only taken for freshwater water bodies and not marine

- **Keenjhar Lake**

  The Keenjhar Lake water quality is not well suited for aquaculture as reported by Pescode 1977 and WHO. Although the TDS and pH are within acceptable range, the Lead and Phenol have found very high quantity. The two main sources of dissolved oxygen in stream or canal water are the atmosphere and aquatic plants. Aquatic plants introduce oxygen into stream water as a byproduct of photosynthesis. The

amount of oxygen that can dissolve in water is limited by physical conditions such as temperature and atmosphere pressure.

Fish growth and activity usually require 5-6 mg/l or ppm of dissolved oxygen. In this study, the Dissolved Oxygen (DO) has been found below or near 2.0 mg/l (ppm) which does not support fish at all. Other pollutants such as sewage, industrial effluents or agricultural runoff result in the build up of organic matter and the consumption of dissolved oxygen by microbial decomposers as they break down the organic matter.

- **Chotiari Reservoir**

  The minimum Dissolved Oxygen (DO) level that Fish can safely tolerate depends upon temperature and to some extent the specie types. As a rule of thumb, Dissolved Oxygen (DO) should be maintained above 3.0 mg/l for warm water fish and 5.0 mg/l for cold water fish. Prolonged exposure to low, non -lethal levels of DO constitute a chronic stress and will cause fish to stop feeding, reduce their ability to convert ingested food in to fish flesh, and make them more susceptible to disease.

  The good quality surface water normally have dissolved oxygen as high as 9 mg/l (depending upon pH and temperature).The dissolved oxygen is found above 3.0 mg/l, Phenol within acceptable limit of 0.02 mg/l. Lead level is also less than 0.1 mg/l All these parameters along with TDS (less than 1000 mg/l) are sufficiently supporting to fish culture. It is also observed that the phenols have decreased to some extent after rain fall.

  The water quality of Bakar Lake in terms of TDS, Phenol and Lead is suitable for fish development. However, the DO is at the marginal level and fluctuates around 2.0 mg/l. The water quality of Dongrion and Patherio Lakes is hazardous for fishery in light of above parameters.

- **Pai Forest**

  The Samano Rahoo Lake is an artificial lake in the project area which, support the livestock, wild life and fisheries in Pai Forest. This lake receives fresh water intermittently from the canal supplies. The samples taken from the lake prior to monsoon indicate acceptable quality, (in terms of TDS, Phenol and Lead) for fisheries, as reported by Pescode (1977) and livestock as per FAO guidelines.

  In June 2007, before monsoon Samano Rahoo Lake was full, while after monsoon, surprisingly the lake had less water, there was no flow from the watercourse. This also indicates that there is no significant role of rain water. The water which was available in the lake after the monsoon period is in fact the seepage water coming from the adjacent agricultural lands. Because of the seepage in the lake, the magnesium and calcium salts level (of sulphates, chlorides) has increased after monsoon (sample PF-A3). The turbidity, phenol and other metals, except the Chromium, also were found high in the lake. The lake is only surface water available to livestock and wild life of Pai Forest. The frequent entry of livestock into the lake for drinking and resting resulted in erosion of lake banks, causing high turbidity. The plant tree

leaves and washing materials (detergents, etc) used by women along the lake may be the cause of phenol based substances. There is no industry or visible source of metallic pollution. The inherent Indus River pollution due to the upstream human activities may be one cause of lake contamination Conclusion

- **Keti Shah**

  The Shah Belo Lake is connected with the Indus River upstream of Sukkur Barrage and moves through the forest, having high quality of water for fish, wild life and livestock. This and river Indus samples show the dissolve oxygen is between 1-2.6 mg/l, which is low , as normally more than 4 mg/l DO is required for the sustenance of the fisheries. The values of TDS, Phenol and Lead are within the acceptable range, as proposed by Pescode.

Table 58 – water quality parameters over site and season

	Keti Bunder		Keenjhar Lake		Chotiari reservoir		Pai Forest		Keti Shah	
Parameters	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon	Pre monsoon	Post monsoon
Temperature	25-29oC	30-32oC	30-32oC	25-29oC	30-32oC	25-29oC.	30-32oC.	25-29oC.	n/a	25-29oC.
Electrical Conductivity	1502-48400 µS/cm.	47200-52700 µS/cm	490-587 µS/cm	529-674 µS/cm,	553-39500 µS/cm	571-15400 µS/cm.	772-810 µS/cm.	760-3430 µS/cm	n/a	287-427µS/cm.
TDS	962-36608 ppm	30208-33728 ppm	314-376 ppm	356-432 ppm	354-25280 ppm	366-9856 ppm	490-519 ppm.	495-2196 ppm	n/a	184-274 ppm
pH	7.16-8.00	7.93-8.81	6.96-8.49	8.00-8.31	7.3-8.9	7.20-8.36	7.62-8.47	7.43-7.94	n/a	7.50-7.80
Turbidity	12.7-94.0	13.2-471	0.73-8.14	3.11-97.2	0.83-17.5 NTU	2.00-40.0	4.04-188 NTU	3.10-833 NTU	n/a	1.50-400 NTU
Total Hardness	300-5000 ppm	5504-5804 ppm	120-155 ppm	60-127 ppm	100-3450 ppm	105-3000 ppm	190-250 ppm	150-444 ppm	n/a	60-120 ppm
Calcium	100-1000 ppm	900-1100 ppm	72-80 ppm	25-45 ppm	50-1600 ppm.	40-310 ppm.	110-170 ppm	75-144 ppm	n/a	30-80 ppm
Magnesium	200-4200 ppm	4604-4704 ppm	43-80 ppm	35-89 ppm	40-3400 ppm	65-2690 ppm	140 ppm.	75-300 ppm	n/a	30-47 ppm
Sulphate	100-13380 ppm	1650-1780 ppm	14-24 ppm	80-170 ppm	75-3450 ppm.	62-1125 ppm	75-175 ppm.	100-1150 ppm	n/a	10-55 ppm.
Chlorine	350-20000 ppm	18000-20000 ppm	28.9-63.5 ppm	50-106 ppm	150 -14000 ppm.	100-2250 ppm	29.8-97.3 ppm	55-350 ppm	n/a	24-54 ppm
Alkalinity	120.0-898.0 ppm.	113-113 ppm.	91.5-109.8 ppm	30-40 ppm	30-330 ppm	80-460 ppm.	40-110 ppm.	73-123 ppm.	n/a	35-70 ppm
Phenols	34-340ppb	34 ppb	1.7-3.57ppb	3.4-15.3	6.8-510ppb	5.1-74.8ppb	8.5-17ppb	8.5-51.0 ppb	n/a	8.5-8.5ppb
Cr	3.53-12.64 ppm	10.44-41.32 ppb	9.3-33.29 ppb	6.4-20.8 ppb	n/a	30-72.6 ppb	53.92-56.02 ppb	23.3-53.9 ppb	n/a	8.99-15.9 ppb
Pb	8.08-75.84 ppm	16.20-17.20 ppb	5.19-10.11 ppb	10.93-20.63 ppb	n/a	6.82-14.6 ppb	23.70-27.50 ppb.	9.65-13.06 ppb.	n/a	21.31-33.85 ppb.
Cd	11.2-64.0 ppb	2.20-2.92 ppb.	4.28-9.16 ppb	0.61-4.74 ppb	n/a	0.66-2.45 ppb.	20.05-21.77 ppb.	0.28-0.98 ppb.	n/a	1.95-5.75 ppb
Ni	12.2-35.21 ppb	6.5-7.8 ppm	7.73-9.82 ppm	0.93-1.73 ppm	n/a	2.32-9.59 ppm	17.05-19.75 ppm	3.48-27.9 ppm	n/a	0.82-1.73 ppm
BOD	0.53-12.4 ppb	3.05-8.75 ppm	5.06-10.1 ppm	1.00-6.07 ppm	n/a	1.76-4.58 ppm	n/a	n/a	n/a	1.26-1.52 ppm
COD	1.9-25.9 ppm	9.2-51.5 ppm	12.64-16.43 ppm	5.05-12.13 ppm	n/a	5.16-11.15 ppm	n/a	n/a	n/a	8.85-19.10 ppm
Arsenic	n/a	n/a	n/a	n/a	n/a	25-50 ppb	30-77 ppb	25-75 ppb	n/a	
DO	n/a	n/a	n/a	n/a	0.18 to 4.92 mg/l	1.5 to 3.2 mg/l	n/a	n/a	n/a	1.4 -2.3 ppm
Nitrates	n/a	n/a	n/a	n/a	n/a	0.182 and 0.345 mg/l.	n/a	n/a	n/a	n/a
Phosphate	n/a	n/a	n/a	n/a	n/a	0.42 and 0.52 mg/l.	n/a	n/a	n/a	n/a

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Our Mission

WWF - Pakistan aims to conserve nature and ecological processes by:

- Preserving genetic, species and ecosystem diversity
- Ensuring that the use of renewable natural resources is sustainable, both now and in the longer term
- Promoting actions to reduce pollution and the wasteful exploitation and consumption of resources and energy

Vision of the Indus Ecoregion Programme

"Mankind coexists with nature in complete harmony and biodiversity flourishes in its respective habitat"

Indus for All Programme, WWF - Pakistan
Programme Management Unit (PMU)

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