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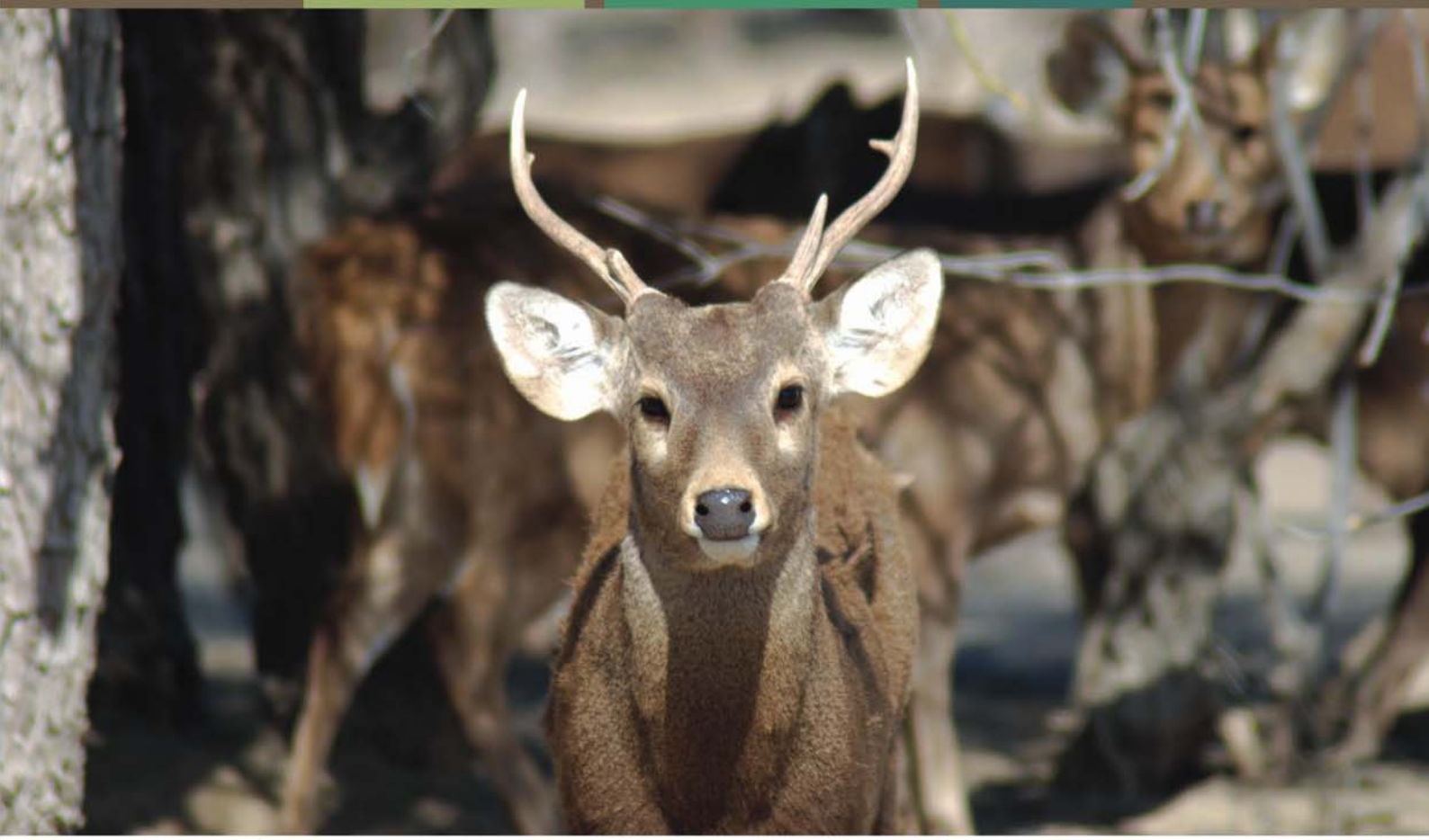
Indus FOREVER

Detailed Ecological Assessment of Fauna, including Limnology Studies at Pai Forest

2007 - 2008



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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
COD	Chemical Oxygen Demand
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.
GEM	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
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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EXECUTIVE SUMMARY

Large mammals:

Pai Forest: Spending eight days in the field (four days during summer survey in June 2007 and another four days during winter in January 2008) a total of 27 animals of eight different species belonging to 2 orders (Carnivora and Artiodactyla) were recorded from Pai forest. Out of the total eight species recorded from Pai Forest, six species (Asiatic jackal, Small Indian mongoose, Grey mongoose, Small Indian civet, Hog deer and Indian wild boar) were observed directly while the remaining two species (Jungle cat and Bengal fox) were recorded on the basis of indirect evidences such as the presence of fecal materials and interviews of local residents and wildlife watchers from Sindh Wildlife Department.

Keti Shah: A total of 22 animals of 11 different large and medium sized mammalian species, belonging to three orders (Carnivora, Artiodactyla and Cetacea) were recorded from the study area. Out of 11 species of large mammals, recorded from the study area, five were observed directly while the remaining six 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 11 recorded species, one is Endangered (E), one is Vulnerable (VU), 5 Near Threatened (NT) and 4 Least Concern (LC) according to the IUCN Red List of Pakistan Mammals 2005. Jungle cat, small Indian mongoose and Small Indian civet are enlisted as Least Concern (LC) in IUCN international Red List 2006. Jungle cat, Indian otter, Small Indian civet, Hog deer and Indus dolphin are protected (P) in Sindh.

Small mammals

Pai Forest: A total of 14 species were recorded from Pai Forest and its surroundings, out of which 11 species were recorded in summer and 11 species in winter. The 14 species belong to 5 orders (Rodentia*, Insectivora, Lagamorpha and Chiroptera*) and 6 families. A total of 9 species were recorded from Keti Shah and its surroundings, out of which all were recorded in summer. The 14 species belong to 3 orders (*Rodentia, Insectivora and Chiroptera*) and 6 families. Keti Shah: A total of 9 species were recorded from Keti Shah and its surroundings, out of which all were recorded in summer. The 14 species belong to 3 orders (*Rodentia, Insectivora and Chiroptera*) and 6 families

Reptiles and amphibian

Pai Forest: As a result of summer studies, 13 species of amphibians and reptiles out of 47 species possibly occurring in the area, were observed or collected by the author and his team, and the remaining were identified through the local inhabitants after thorough discussions as well as by the earlier records in the literature. The studies were repeated in winter season for the maximum likelihood of the recording of herpetiles. It resulted in the addition of five species of reptiles increasing the number to 18. The species collected during winter studies included a single species of gecko *Cyrtopodion scaber*, lacertid lizard *Ophisops jerdonii*, colubrid snake *Platyceps v. ventromaculatus* and two species of skinks *Eutropis dissimilis* and *Eurylepis t. taeniolatus*. The amphibians are represented by three species belonging to three genera and two families. Among the reptiles, chelonians are represented by single species belonging to family Trionychidae. Lizards are the second dominanat group of herpetiles, represented by 19 species belonging to 13 genera and seven families. Snakes outnumber all the groups of reptiles in the study area and are represented by 24 species belonging to 18 genera and six families.

Keti Shah: Various localities in the forest were visited and both day and night surveys were conducted from 20 to 21 June 2007. Population of Brown River turtle *was* higher than any other turtle species. Bengal Monitor was one of the most frequently seen lizards in the forest. Similarly, Marbled toad population was the highest of all the amphibian species of the area. Checkered keel-back was the only snake observed during the summer studies. The studies conducted in the beginning of winter season resulted in finding several new species, previously not reported. In the summer studies, out of 53 possibly occurring species of the area, 11 species of amphibians and reptiles were observed or collected and the remaining were identified through the local inhabitants after thorough discussions as well as by the earlier records in the literature. The studies were repeated in the beginning of winter season and the author observed and collected five additional species of herpetiles including a single species of freshwater turtle *Kachuga tecta*, Gecko *Hemidactylus brookii*, colubrid snake *Ptyas mucosus* and two species of Elapids *Bungarus c caeruleus* and *Naja n. naja*. The table below provides the picture of current field studies conducted in different localities in and around the forest.

Phytoplankton

Pai Forest: Survey of algal species from Pai forests was carried out w.e.f. 20 to 21 June, 2007. A total of 67 Algal species belonging to 32 genera of 6 phyla Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Euglenophyta and Chlorophyta. A total of 33 (49.2%) species belong to 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 and 25 algal sample were collected during November 2007 out of the 71 species belonging to 34 genera of 7 phyla e.g. Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta, Charophyta along with 17 aquatic plants and some physico-chemical parameter were recorded, water is rich in primary productivity and plant production. To know the reason about plants/cryptogams like algal species reduced and some species their indications. While difference species have various value from point of importance like some species are useful for medicine, nitrogen fixing, vitamins, toxic, for oil, pollution, water quality, hard, soft, alkaline as well as food produced species were recorded.

Keti Shah: A total of 128 Algal species belongs to 62 genera of eight phyla during field trip from Shahbella Riverine area of Sukkur were recorded. 38 species 29.7% belonging to 17 genera of phyla Cyanophyta, 41 species 32% belonging to 17 genera of phyla Volvocophyta, 32 species 25% belonging to 15 genera of phyla Bacillariophyta, 2 species 1.6% belonging to 2 genera of phyla Xanthophyta, 2 species 1.6% belonging to 2 genera of phyla Dinophyta, 3 species 2.3% belonging to 2 general of phyla Euglenophyta, 8 species 6.3% belonging to 6 genera of phyla Chlorophyta. 2 species 1.6% belonging to one genus of phyla Charophyta and more than 50 algal samples were collected during November 2007. A total of 132 algal species belonging to 61 genera of 8 phyla namely Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta etc. were recorded, water is rich in primary productivity and plant production. To know the reason about plants/cryptogams like algal species reduced and some species their indications. While difference species have various value from point of importance like some species are useful for medicine, nitrogen fixing, vitamins, toxic, for oil, pollution, water quality, hard, soft, alkaline as well as food produced species were recorded.

Water quality:

Pai Forest: Pai Forest is situated in District Nawabshah and covers an area of 1,933 ha of irrigated plantation. The forest provides a natural habitat for different wildlife species. Prior to construction of Sukkur Barrage in 1932, the forest was irrigated by River Indus water during inundation. After construction of protective bunds the forest was cut off from the riverine areas and became inland forest and irrigation water was sanctioned from Rohri Canal. But due to various reasons the forest was unable to receive canal irrigation water supply and thus Forest Department, Government of Sindh installed 13 tube wells. Out of 13 tube wells now seven tube wells are irrigating and other six tube wells are non functional. The rainfall in the study area is sparse. The main livelihood of the population surrounding Pai Forest is agriculture and livestock rearing. The main source of drinking water in Pai Forest area is the groundwater. The samples taken from the study area indicate that the water quality in most of the parameters is well within the WHO Drinking Water Quality Guidelines except the Arsenic, which is toxic and detrimental to the health of people. 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 good for the forest. The pH value is also in the good range (6.5-8.5). Therefore this water can be considered for Non Degree of Restriction of Use. Also this water quality is an excellent for all livestock and poultry as per FAO guidelines. The Samano Rahoo Lake is only one (artificial) lake in the project area which, support the livestock, wild life and fisheries. This lake receives fresh water intermittently from the canal supplies. The sample taken from lake before monsoon indicate good quality, (in terms of TDS, Phenol and Lead) for fisheries, as reported by Pescode (1977) and livestock as per FAO guidelines . After monsoon, surprisingly the lake had less water, because there was no flow coming from the canal water. The water which was available in the lake after monsoon period is in fact the seepage water coming from the adjacent agriculture lands. Because of seepage in lake, the magnesium and calcium salts level (of sulphates, chlorides) has increased after monsoon. The turbidity, phenol and other metals, except the Chromium, also were found high in the lake. 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 are no industrial or and visible source of metallic pollution.

Keti Shah: Also known as “Shah Belo” is located in Sukkur District. It covers an area of 7,346 ha. Keti Shah Forest is managed for wood production, seed collection and for practical field training area for forest trainees through out Pakistan. It is a thick plantation forest which receives frequent water from the River Indus at upstream of Sukkur Barrage. Apparently no serious problem of water deficit was observed during field visit for sample collection. The rainfall in the study area is very small and varying from time to time. The main livelihood of the population surrounding Keti Shah Forest is agriculture, fisheries and livestock.

The ground water of Keti Shah as samples from two locations indicates that the water quality in almost all parameters is well within the WHO Drinking Water Quality Guidelines. The two surface water samples were also equally good with some little fluctuations. 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 good range (6.5-8.5). From this, it appears that this water can be considered for Non Degree of Restriction of Use. Also the salinity (TDS) of both ground water and surface water is well below 1000 mg/l, which is excellent as useable for all livestock and poultry as per FAO guidelines. It is recommended that to protect the people

from the Arsenic, which is toxic and detrimental to the health of people, an awareness programme may be launched through the field team. Further, suggested that the filters developed by researchers at Massachusetts Institute of Technology (MIT), Environment and Public Health Organization (ENPHO) of Nepal, and Rural Water Supply and Sanitation Support Programme (RWSSSP) of Nepal, may be introduced in the area to protect them from Arsenic hazards.

Chapter: Introduction

1.1 Brief History of the Pai Forest plantation

Map 1 – Map of Pai Forest

Prior to British era in 1943, the local rulers (Talpur/Mirs) in Sindh owned all the well-stocked forests in the province, who maintained them as hunting grounds. The cutting of trees in such forests was strictly prohibited. Creation and demarcation of state forests (as reserve and protected forests) was started in 1823 and continued till 1972. Pai Forest is situated on eastern side of the River Indus near Sakrand town of district Nawabshah in Sindh Province at about a distance of 5 km adjacent to National Highway.

Pai forest has a total area of 1933 ha (4,777 acres). Out of the total area only 1,502 ha (78%) are under tree cover while remaining 319 and 112 ha are either blank or on high lying areas, respectively. Presently 338 ha (17 %) are under Babul (*Acacia nilotica*), 107 ha (6 %) under *Eucalyptus*, 1,045 ha (54%) under Kandi (*Prosopis cineraria*) and 12 ha (0.6%) under Shisham (*Dalbergia sissoo*) crop. Thus a total of 457 (24% of the total area) is irrigated and maintained as Irrigated plantation while remaining area (54 %) that is comprised of Kandi (*Prosopis cineraria*) trees does not receive irrigation water.

Climate of this area is generally hot and arid. Rainfall is scanty, erratic and mostly occurs during monsoon season *i.e.,* from June to September. The average annual rain fall is about 200 mm. Maximum temperatures in summer rises to 50^{o}C, and minimum temperature during winter is 8^{o} C. Hot summers usually extend from April to October. The Soil of this area is mostly loamy in nature with varying proportions of clay and sand. Most of the area has high salt concentrations due to hyper aridity and scarcity of irrigation water.

Prior to the construction of Sukkur barrage on River Indus at Sukkur, Pai forest depended for its water supply on the scanty rainfall and the unregulated water

supply from the river through inundation channels. As water supply was not assured, the growing stock was poor both in quality and quantity. The Barrage was constructed during 1931-35, but no provision was made initially for supply of water to the Pai Forest. Establishment of tree plantations under agro-forestry system was, however, started in 1937-38 with the help of irrigation water. As water supply was small, only small areas of 20 to 40 ha were taken up each year for raising tree crops. This arrangement continued till 1946-47.

Due to construction of flood protection bund on the river, Pai forest has cut off from the riverine areas and became inland forest. Thus this inland forest is situated outside the river embankments. Realizing the gravity of the shortage of fuel-wood and charcoal in the province in 1946-47, the Government of Sindh sanctioned irrigation water from Rohri canal for maintaining Pai forest. It is presently partly irrigated by canal water and partly by tube wells.

Due to its ecological importance this plantation has been declared as a protected area (Game Reserve) by Sindh Wildlife department for conservation and sustainable management of wildlife and its habitat because it provides abode to different wildlife species. Important wildlife of the area includes Hog deer, Partridges, Asiatic jackals, Jungle cat, Porcupine, Wild boar, Snakes, etc. For this purpose Pai forest, was taken up for systematic conversion into irrigated plantation during 1960-61 under a development scheme titled "Industrial Wood Plantation Phase-I". An area of 506 ha was planted under this scheme. In addition, an area of 174 ha was planted under Industrial Wood Plantation Phase-II in 1988-91 and 455 ha planted under SFDP in 1996-97. Most of the areas planted with Shisham during 1960-61 to 1969-70 under first development scheme were invaded by Kandi (*Prosopis juliflora*) due to fires and shortage of canal water. Therefore, 13 tube wells were installed in Pai plantation to irrigate during water shortage periods but they are inadequate to support the entire game reserve.

1.1.1 State of Biodiversity

- **Habitat:** This forest is dominated by four major species like Kandi (*Prosopis cineraria)* (very common with pure stands), Babul *(Acacia nilotica)* (common), *Eucalyptus camaldulensis* (Common), and *Tamarix spp*. (*Tamarix indica* (Common) and *Tamarix aphylla* (occasional). Whereas other species in the area include *Salvadora oleoides, Salvadora persica, Calotropis procera, Cadaba farinosa, Zizyphus nummularia, Capparis decidua, Amaranthus graecizans, Cucumis melo var. agrestis, Zaleya pentandra, Solanum surattense, Corchorus tridens, Corchorus depressus, Abutilon indicum, Amaranthus viridis, Launaea procumbens, Brachiaria spp., Suaeda fruticosa, Rhynchosia minima, Mullugo pentaphylla, Salsola imbricata, Dactyloctenium aegyptium, Desmostachya bipinnata, Trianthema portulacastrum, Euphorbia prostrata, Eclipta alba, Eragrostis japonica, Eragrostis minor, Cleome brachycarpa, Aerva javanica* and *Cocculus hirsutus* etc.

- **Wildlife:** The major wildlife species in this game reserve include Hog deer, Partridges, Asiatic jackals, Jungle cat, Porcupine, Wild boar, Snakes, Desert hare, Rodents, Bats, Indian grey mongoose, Pangolin, Indian Bengal fox, etc. Whereas common birds include Green finch, Red vented bulbul, White cheeked bulbul, Pied chat, Pheasant tail crow, Grass

tailed prinia, Turtle dove, Jungle babbler, Jungle sparrow, Crested lark and Finch lark.

- **Agriculture** is one of the major professions in the area. People grow wheat and fodder as winter season crops while cotton is the summer season crops. Cultivated woody perennials and herbs are given below in **Table 1**.

Table 1 – Cultivated plant species recorded at Pai Forest

S.no	Family	Plant species	Life form	Habitat
1	Acanthaceae	*Adhatoda vasica* Nees	Phanerophyte	Shrub
2	Combretaceae	*Terminalia arjuna* Wight & Arn.	Phanerophyte	Tree
3	Fabaceae	*Sesbania bispinosa* (Jacq.) W.F. Wight	Phanerophyte	Subshrub
4	Labiatae	*Ocimum basilicum* L.	Chmaephyte	Subshrub
5	Meliaceae	*Azadirachta indica* A.Juss.	Phanerophyte	Tree
6	Myrtaceae	*Eucalyptus camaldulensis*	Phanerophyte	Tree
7	Papilionaceae	*Dalbergia sissoo* Roxb.	Phanerophyte	Tree
8	Papilionaceae	*Erythrina sp.*	Phanerophyte	Tree
9	Pedaliaceae	*Sesamum indicum* L.	Therophyte	Herb
10	Sapindaceae	*Dodonaea viscosa* (L.) Jacq.	Phanerophyte	Shrub

1.1.2 Livelihood and social aspects

The local communities of the surrounding area belong to Chandio, Jamali, Keerio, Lakha, Bhumbro and Jalbani tribes. Their livelihood is agriculture and mainly depends on forest area for their wood requirements and livestock grazing.

In recent past, all of the riverine forests namely Mehrabpur, Maribelo, Moriolakho, Jaryoketi, which were about 20000-25000 acres, lying outside the protection bund have been totally encroached by local peoples. Now the pressure of surrounding villages (20-25 villages) is entirely on Pai forest for fuel, timber, hunting and grazing. This small chunk of land is the only refuge for dwindling population of Hog deer and other fauna of the area. On the other hand the same forest is also sole source of fire wood, timber and grazing land for surrounding communities. This situation has aggravated the pace of continuous degradation of forest and wildlife habitat. Keeping in view the ecological importance of this forest, WWF- Pakistan took up this site for conservation and rehabilitation on sustainable basis.

Villages around Pai forest have a mix of ethnic groups including Sindhi Samat castes such as Channa, Keeria and Machhi; Baloch tribes such as Magsi, Leghari, Zardari, Jamali and Jalbani; and Punjabi / Seraiki casts such as Gudara, Sial, Bhutta, Arain and Gujjar. The main livelihood sources are agriculture, livestock, and government service. School education infrastructure is widespread but health facilities are sporadic. Water supply through hand pumps is available and so is electricity in most villages. The area also has local civil society organizations and advocacy groups, in addition to the CCBs.

A recent socio-economic study undertaken by the Indus for All programme revealed that Marri Jalbani is the largest village, the residents of which are reportedly involved in wood cutting and selling. Provision of gas to this village and other nearby communities is likely to reduce the wood cutting intensity to a

considerable extent. Livestock ownership in most villages coupled by herds brought by tribesmen from Upper Sindh also threatens the irrigated plantation in Pai forest area. The average household size of the neighboring rural population is 6.9 members. Large household sizes are of 14 to 18 or even of more members in the nearby villages. About half (49%) of houses are Katcha, while a significant proportion of houses (27% and 19%) respectively, are semi-Pacca (bricks and wood) and Pacca (bricks and iron or RCC structure. Agricultural labor and services are prominent professions of the population of Pai forest site along with miscellaneous services and occupations. About one half of the family members of Pai households are engaged in service sector followed by 36% as agricultural labor. On an overall basis, the main occupations of family members other than the household head, were fishing (36.4%), agricultural and wage labor (32%) and miscellaneous labor oriented services (23%). It is clear from these indicators that the human capital is quite low over here. Most of the people are engaged in primary production sectors of agriculture and fishing and in labor oriented occupation.

Average monthly income per household is estimated as Rs. 7,000 only. Almost 52% households own buffaloes for milk. The average number of milking cows is 1 per household. Goat, sheep, and camel ownership are found as 22%, 9% and 5% households, respectively. Poultry birds are maintained by 16% of the households. Donkeys and horses are reported by 1.5% and 0.5% households, respectively.

Based on recent socio-economic assessment conducted by Indus for All Programme, on an overall basis, 48% of respondents agreed that irrigation water resources have depleted during the last five years. Over 64% respondents agreed that forest resources have sharply depleted during the last 5 years.

1.2 Keti Shah

Keti Shah is a riverine forest and the riverine forests in Sindh now exist only upstream of Sukkur barrage. Riverine forests are the most typical forests of Sindh, occupying a total land area of about 0.596 million acres or 1.71% of the province. The construction of upstream dams and barrages has consistently reduced the river flows adversely affecting riverine forests. It was reported that about 40% of the riverine area is now blank and under other uses (Indus for All Programme 2008). At present, the inundated riverine area has transformed into more or less a perennial cultivated area, where a variety of crops is cultivated.

Keti Shah Forest also known as Shah Belo is a typical example of deteriorating forest cover. It is located upstream of Sukkur city and spreads over an area of 7,346 ha. It is notified as Reserved Forest since 1912 and is contiguous with other riverine forests viz. Ding (655 ha), Bindi Dhareja (2,940 ha), Qadarpur (858 ha) and Pahwari. Keti Shah Forest is managed for wood production, seed collection and for practical field training area for forest trainees (SFD 2001).

Keti Shah Forest comprises of 122 compartments and the River Indus passes from the center of the forest dividing the forest in two parts. North-western part of the forest covers 52 compartments while the south-eastern part covers 70 compartments. There are twelve villages in the forest with a population of about 7,500 (SFD 2001). The villages in the Keti Shah area are devoid of basic human needs like health and education facility.

Keti shah Riverine forest also known as "Shah Belo" falls in Sukkur Afforestation Division spread over an area of 7,343 hectares and notified as "Reserved Forest" since 1912. The forest is managed for wood production, seed collection and for practical field training area of forest trainees

Keti Shah Riverine Forest known as "Shah Belo" is located in Sukkur District (Afforestation Division) and is spread over an area of 7,346 hectares. It is notified as 'Reserved' forest since 1,912 and is contiguous with other Riverine forests namely Ding (655 ha), Bindi Dhareja (2,940 ha) Qadrapur (858 ha) and Pahwari. Keti Shah Forest is managed for wood production, seed collection and for practical field training area for forest trainees throughout Pakistan. Regular planting of this forest is carried out and there is very small number of animals found.

1.3 Rationale and Objectives

13.1 Large Mammals Survey

1.3.1.1 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.

1.3.1.2 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.

1.3.2 Small mammal survey

1.3.2.1 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.

1.3.2.2 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.

1.3.3 Reptiles and amphibians survey

1.3.3.1 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.

1.3.3.2 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 behavior 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.

1.3.4 Birds survey

1.3.4.1 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.

1.3.4.2 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.

1.3.6 Phytoplankton

1.3.6.1 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.

1.3.6.2 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.

1.3.7 Zooplankton

1.3.7.1 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.

1.3.7.2 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.

1.3.8 Physicochemical properties of water

1.3.8.1 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.

1.4 Literature Review

1.4.1. 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. Roberts (2005) published Field Guide to the Large and Medium sized 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 mammal 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 through Consultants MMP – NESPAK – ACE in 1997 (EMMP Report 1998). These studies made a situation analysis of the wildlife including mammals in Chotiari 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.

1.4.2 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).

1.4.3 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.

1.4.4 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 Baluchistan 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 Sindh. 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.

1.4.6 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 evident 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 climatic 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 climatologically 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 phenomenon 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 pattern (*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

1.4.7 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.

1.4.8 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 Paleartic 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 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 Appendix I.

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).

2.1.3 Roadside counts

Roadside counts technique was applied at Keenjhar Lake mostly for the nocturnal mammals like foxes, jackals and cats. Additionally this technique was used in Keenjhar Lake as a means to locate different nocturnal mammals using search lights on 4x4 jeeps as well as diurnal mammals like mongooses.

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 at Keenjhar Lake this technique was applied just for the confirmation of the presence of nocturnal mammals.

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 at Keenjhar Lake for Jackals.

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 Capture-mark-recapture

This method is applied by using vocalization frequency to estimate the size of different animals' populations is also an effective method. The technique involves walking along fixed transects to disturb all animals present on a study plot, potentially provoking a vocal response. Those animals heard to vocalize (whether observed or not) are then considered the total number of "marked" individuals in the population. The proportion of "marked" individuals in the population is estimated from the proportion of animals that vocalize in the sub sample of individuals observed (the vocalization frequency). Population size is estimated by dividing the number of marked individuals by the vocalization frequency. If the assumptions are met, this method provides estimates of absolute population size at low cost and with little material investment, because physical capture and marking of animals is not necessary (Reby 1998). Using this technique at Keenjhar Lake, the populations of Jackals were estimated.

2.1.9 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. This technique was applied near Jaakhra fish ponds at N 24 52 282 and E 68 02 693

2.1.10 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

Table 2 – Locations used for sampling in Keenjhar Lake

S.no	Keenjhar Lake		
1	Northing	Easting	Location name
2	24 50 817	67 57 117	Jhangli Kooa
3	24 50 817	67 57 117	Jhangli Kooa
4	24 50 817	67 57 11	Noriro/Nor
5	24 50 81	67 57 117	
6	24 50 817	67 57 117	Karo Kooa
7	25 03 955	68 07 36	Sehar
8	24 46 295	67 56 457	Fusli Kooa
9	24 46 295	67 56 457	Fusli Kooa
10	25 01 898	68 03 939	Kundyara Kooa
11	24 52 262	67 59 288	Makli graveyard

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 colored. 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.

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 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.

2.3.4 Collection

Hand picking (through bare hands or with the help of long forceps or snake clutch), adopted for the present studies, has always been the most efficient way of collecting different species of 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.

2.3.5 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.

2.3.5 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.

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

2.3.7 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 transversed / 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.

c) 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 Phytoplankton

2.5.1 Collection methodology

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).

2.6 Zooplankton

2.6.1Collection 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.

2.6.2 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.

2.7.8 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.

2.8 Physico-chemical properties of water

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 colored 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 on next days with proper custody protocol.

2.8.1 Materials and methods

The water samples from the study areas were collected using standard water samplings protocols 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 heavy elements as well as Arsenic. All samples were properly sealed under specific codes/labels and dispatched to the water quality laboratory for analysis. A random sampling strategy was designed according to the site conditions and in consultation with WWF teams deployed at study areas. The location points and their significance are highlighted in **Tables 3** and **4**. The sample location points were marked on each bottle. The sample location points were marked on map through GPS. These points will be used as baseline in future studies. The technique and methodology used for analyzing the samples are given in the annexure document as are the policy documents, TORs and work plan.

Table 3 – Significance of Sample Location Points at Pai Forest Area

S. no	Sample number	Sample Location	Significance
1	PF-B1	Tube well at Chokri 15	Groundwater (GW) is the only source of water for the survival of the forest., this is also used for drinking It is important to judge GW quality
2	PF-B2	Tube well at Chokri	Test groundwater quality at the other end of the forest area.
3	PF-B3	Samano Rahoo Lake inside forest area	Lake being used for the fishery and livestock. Lake gets water not often from the canal water hence seepage water enters in to the lake and deteriorates the water quality

Table 4 – Significance of Sample Location Points at Keti Shah Forest Area

S.no	Sample number	Sample Location	Significance
1	KTS-A1	Groundwater	Test groundwater quality, because people are using this hand pump for drinking
2	KTS-A2	Groundwater	Test 2nd hand pump GW quality, because people are using this for drinking
3	KTS-A3	Shah Belo Lake	Lake being used for fishery and livestock. Lake gets water from River Indus
4	KTS-A4	Indus River at Upstream Sukkur Barrage	River Indus water which is the source of water for all purposes

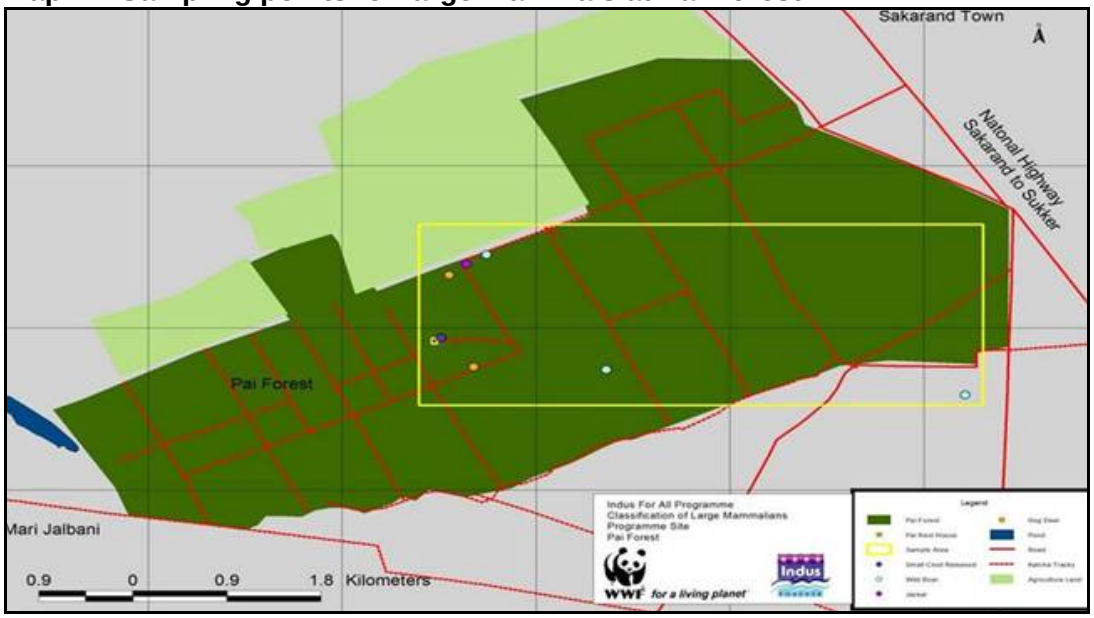
Chapter 3: Findings and discussion

3.1 Large mammals (Pai Forest)

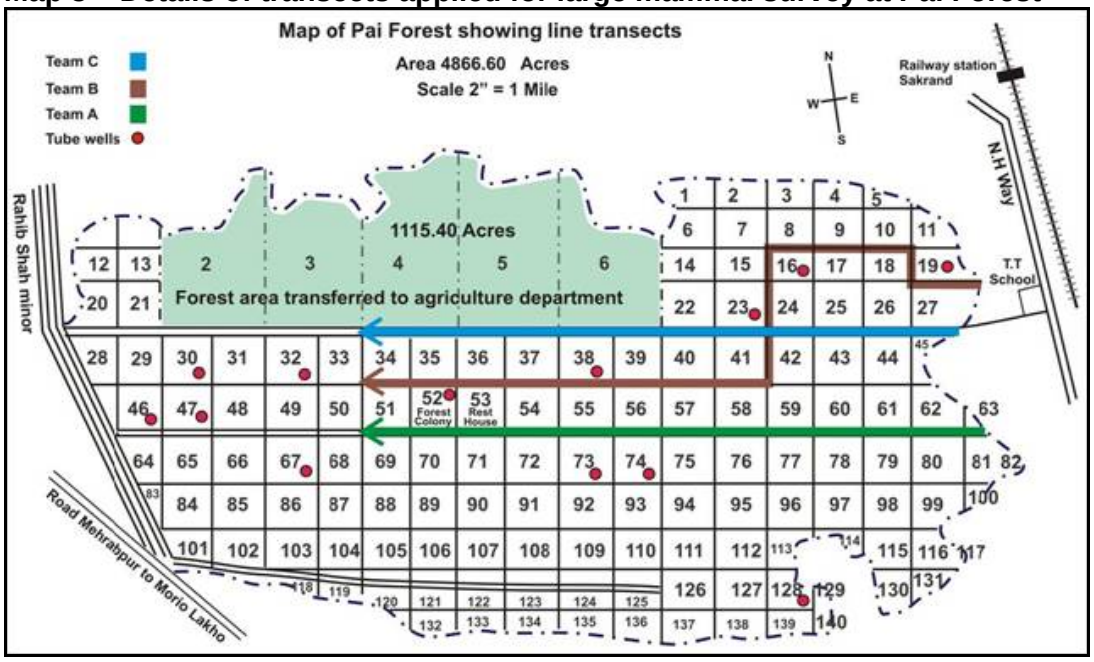
3.1.1 Sampling locations

During the present studies, about 25% of the total area (35 out of 140 compartments) was surveyed in the Pai Forest. Different sampling sites and the distribution of large mammals in Pai Forest during summer and winter surveys is shown in **Map 2** and **3** respectively. GPS coordinates taken during summer and winter surveys are given in the annexure document.

Map 2 – Sampling points for large mammals at Pai Forest



Map 3 – Details of transects applied for large mammal survey at Pai Forest



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 in January 2008) a total of 27 animals of

eight different species belonging to 2 orders (Carnivora and Artiodactyla) were recorded from Pai forest as given in the **Table 5**.

Table 5 – List of large mammals recorded from Pai Forest

S. No.	Common Name	Zoological Name	Order	Animals Observed
1	Asiatic jackal	*Canis aureus*	Carnivora	6
2	Jungle cat	*Felis chaus*	Carnivora	-
3	Bengal fox	*Vulpes bengalensis*	Carnivora	-
4	Small Indian mongoose	*Herpestes javanicus*	Carnivora	7
5	Grey mongoose	*Herpestes edwardsi*	Carnivora	2
6	Small Indian civet	*Viverricula indica*	Carnivora	2
7	Hog deer	*Axis porcinus*	Artiodactyla	7
8	Indian wild boar	*Sus scrofa*	Artiodactyla	3

3.1.3 Observation Records

Out of the total eight species recorded from Pai Forest, six species (Asiatic jackal, Small Indian mongoose, Grey mongoose, Small Indian civet, Hog deer and Indian wild boar) were observed directly while the remaining two species (Jungle cat and Bengal fox) were recorded on the basis of indirect evidences such as the presence of fecal materials and interviews of local residents and wildlife watchers from Sindh Wildlife Department. The observation records of different mammals found in Pai Forest are given in the **Table 6.**

Table 6 – Observation records of different mammals at Pai Forest

Sr. No.	Species found at Pai Forest	Direct Obs.	Indirect Observations		
			Tracks	fecal material	Interviews with locals
1	Asiatic jackal	✓	-	-	✓
2	Jungle cat	-	-	-	✓
3	Bengal fox	-	-	✓	✓
4	Small Indian mongoose	✓	-	-	✓
5	Grey mongoose	✓	-	-	✓
6	Small Indian civet	✓	-	-	✓
7	Hog deer	✓	✓	✓	✓
8	Indian wild boar	✓	✓	-	✓

3.1.4 Conservation status of mammals of Pai Forest

According to the IUCN International Red List 2006, Jungle cat, Small Indian mongoose and Small Indian civet are categorized as Least Concern (LC). Whereas, according to IUCN Pakistan Red List of Mammals 2005, three species; Asiatic jackal, Bengal fox and Small Indian civet are categorized as Near Threatened (NT), four species; Jungle cat, Small Indian mongoose, Grey mongoose and Indian wild boar are categorized as Least Concern (LC) and one species (Hog deer) is categorized as Vulnerable (VU). Jungle cat, Small Indian civet and Hog deer are protected in Sindh under Sindh Wildlife Protection Ordinance 1972. The conservation status of different mammals found in Pai Forest is given in **Table 7**.

Table 7 – Conservation status of large mammals found in Pai Forest

S No.	Mammalian Species Found at Pai Forest	IUCN International Red List 2006	IUCN Pakistan Red List 2005	Sindh Wildlife Protection Ordinance 1972	CITES Category 2007
1	Asiatic jackal	-	NT	-	-
2	Jungle cat	LC	LC	P	Appendix

					II
3	Bengal fox	-	NT	-	-
4	Small Indian mongoose	LC	LC	-	-
5	Grey mongoose	-	LC	-	-
6	Small Indian civet	LC	NT	P	-
7	Hog deer	-	VU	P	Appendix I
8	Indian wild boar	-	LC	-	-
Legend: E = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, P = Protected					

3.1.5 Population estimations

Population of eight mammalian species at Pai Forest were estimated by applying different techniques such as point surveys, line transects, track counts and interviews of the local residents as well as wildlife watchers from SWD and guards from Sindh Forest Department. The estimated populations of different mammals are given in the **Table 8** below.

Table 8 – Estimated populations of mammals at Pai Forest

Sr. No.	Common Name	Scientific name	Est. Populations	Habits
1	Hog deer	*Axis porcinus*	19	Nocturnal
2	Indian wild boar	*Sus scrofa*	85	Nocturnal
3	Small Indian civet	*Viverricula indica*	6	Nocturnal
4	Asiatic jackal	*Canis aureus*	40	Nocturnal
5	Jungle cat	*Felis chaus*	3	Nocturnal
6	Bengal fox	*Vulpes bengalensis*	5	Nocturnal
7	Small Indian mongoose	*Herpestes javanicus*	40	Diurnal
8	Grey mongoose	*Herpestes edwardsi*	27	Diurnal

3.1.5.1 Population of Hog Deer

For estimating the population of Hog deer in Pai forest, different techniques such as point surveys, line transects, road side counts and track counts were applied. The results of point surveys and track counts techniques were almost similar i.e. a population of 16 to 20 Hog deer in the forest was estimated. The line transects and road side counts methods were not found so helpful in estimating the population of Hog deer in the forest. During point surveys, in November 2006, total five Hog deer were sighted at two different locations. Two Hog deer (1 male, 1 female) were observed in compartment number 64 and 3 (1 male, 1 female and 1 young) in compartment number 57 near cultivated area of the compartment. During summer studies of the forest in June 2007, point survey technique was not applied rather line transect and track count techniques were focused for the estimations of hog deer population.

Image 1 – Tracks of Hog deer in Pai

Image 2 – Pellets of Hog deer in Pai

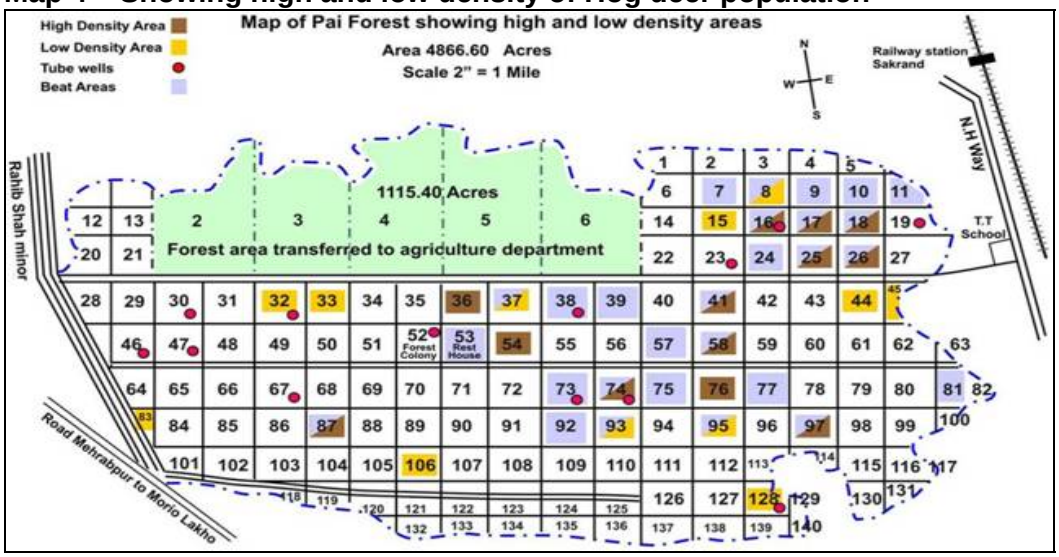
Pai forest is divided into 140 compartments with inter-compartmental dirt roads. Two teams searched different parts of the forest on 4x4 jeeps at night to observe Hog deer. This practice continued for three consecutive nights from 24 to 26 June 2007. These roadside counts were carried out during night from 10:00 pm till 12:00pm by using search lights on top of the vehicles but no animals were observed.

A heavy rain started at about 9:00 pm and stopped at 11:50 pm after about three hours on 26 June 2007 and during this heavy rain all the previous tracks got washed out. As the Hog deer is a nocturnal animal, only the fresh tracks were visible after the rain in the early morning. Keeping this thing in mind, 3 different teams were organized (team A, team B and team C) that traveled through the forest along a predetermined route (Fig. 34) to observe and count the fresh tracks of hog deer. These teams walked across the compartments wherever possible while in other cases they searched the boundaries of the compartments from all the sides to observe the tracks of any animal entering or leaving the compartment. This search started in the early morning about one hour before the sun rise so that the mixing of the livestock tracks (sheep and goat) could be avoided. Fresh tracks of Hog deer were counted from all the potential (high as well as low density) areas in the forest. As the rain stopped at mid night, the number of tracks counted early in the morning might be representing half of the population found in the forest.

It is also observed that Hog deer usually follows the same path for going to and coming back from the feeding grounds especially in the Pai forest. This is because Hog deer finds that path safe which it uses for going to the feeding ground and usually escapes by using the same path when disturbed in the feeding ground. This behavior of Hog deer was also observed in compartment No. 36 where we found the foot prints of one male Hog deer entering and leaving the compartment from the same location, the only difference was that it entered confidently as shown by the tracks while the tracks of leaving the compartment were in running condition showing some sort of threat. No other foot prints were found in that compartment even after searching all around the compartment.

According to the wildlife watchers of Sindh Wildlife Department, 60 compartments out of 140 of Pai forest are potential sites for Hog deer. Because these are the compartments where either the beat areas are established for partridge hunting or these are adjacent to such compartments and different crops are cultivated in such areas that provide the feeding grounds for Hog deer. During the present study, 25 different compartments including 13 from high density areas (No. 16, 17, 18, 25, 26, 36, 41, 54, 58, 74, 76, 87 and 97) and 12 from low density areas (No. 8, 15, 32, 33, 37, 44, 45, 83, 93, 95, 106, and 128) were searched and foot prints of Hog deer were observed in six compartments (Table 50). The selection of high density as well as low density areas in the forest is based on the observations of wildlife watchers and game inspectors from Sindh Wildlife Department. Similarly, the 25 compartments out of 60 were selected randomly to cover all the areas and to have homogenized sampling from the forest.

Map 4 – Showing high and low density of Hog deer population



It is a common observation that is also confirmed by the wildlife watchers of the forest that Hog deer feeds at night such that few animals come into the feeding grounds very early i.e. just before sunset, a few after sunset i.e. in the dark avoiding day light while still others after the mid night and before the dawn and this practice continues during the whole night. The foot prints observed in six compartments represent half of the Hog deer population found in the forest as the animals came out of their hidings after mid night and there are chances that these nine animals are those that use to come in the second half of the night for feeding. Secondly, Hog deer come out of its hiding for foraging very early in the evening even before sunset but as after about just two hours a heavy rain started that night, Hog deer had very short time for feeding. Suppose some animals that remained hungry, came again in the feeding grounds after the rain stopped and if we consider such animals as 50 % of the total population then the number of Hog deer in the forest might be 18 i.e. (**9 x 2 = 18**).

Table 9 – Track counts for Hog deer in Pai forest

Sr. No.	Compartment No.	No. of foot prints observed
1	15	1
2	17	1
3	33	2
4	41	2
5	58	1
6	71	2
Total		**9**

Out of 60 compartments reported as potential sites for hog deer, 25 are among high density areas while 35 among low density areas according to the wildlife watchers from Sindh Wildlife Department. Foot prints of six animals were observed in 13 compartments from high density areas while foot prints of three animals were observed from 12 compartments of low density areas. The number of animals per compartment is thus;

0.23 animals / compartment for low density areas

0.46 animals / compartment for high density areas

Thus: Number of animals in 35 compartments of low density areas;

0.23 x 35 = **8.05**

number of animals in 25 compartments of high density areas;

0.46 x 25 = **11.5**

Total Hog deer population in Pai forest

8.05 + 11.5 = 19.55

In 80 compartments other than potential sites for Hog deer, there are reduced chances of Hog deer presence due to high levels of disturbance due to forest cutting and other human activities. Hence the population in the potential sites reflects the total population in the forest which is around 20 animals.

3.1.5.2 Population of Wild boar

Twenty five compartments searched for Hog deer, were also searched, at the same time, for estimating the population of wild boar in the forest. There are 34 compartments where beat areas have been established for partridges and due to cultivation in these compartments, wild boar is usually seen here (Personal communication with game inspector, Sindh Wildlife Department). Hence, these 34 compartments represent the potential feeding grounds for wild boar.

After a three hours' heavy rain on 26 June 2007 that stopped at mid night, all the previous tracks of wild boar were washed out and only the fresh tracks of the animals were visible in the early morning. Keeping this in mind, three different teams were organized (team A, team B and team C) that traveled through the forest covering all those compartments identified as the potential feeding grounds for wild boar to observe and count the fresh tracks of wild boar. These teams walked across the compartments wherever possible while in other cases they searched the boundaries of the compartments from all the sides to observe the tracks of any animal entering or leaving the compartment. This search started in the early morning about one hour before the sun rise so that the mixing of the livestock tracks (sheep and goat) could be avoided. After careful observations and avoiding any duplication, the foot prints of 20 different animals were observed in eight different compartments (compartment No. 9, 17, 33, 39, 41, 42, 58 and 59).

Table 10 – Track counts records for Wild boar

S.No	Compartment No.	No. of foot prints observed
1	9	1
2	17	3
3	33	2
4	39	4
5	41	3
6	42	5
7	58	1
8	59	1
	Total	**20**

Tracks of 20 wild boars observed in 8 compartments out of 34 potential feeding grounds, suggest the presence of 20 animals at an average of 2.5 animals per compartment. Based upon this, the population of Wild boar in 34 compartments can be calculated as;

20 / 8 = 2.5 animals per compartment
2.5 x 34 = 85 animals in 34 compartments

It should be noted that 85 wild boar in Pai forest will also be using the cultivated areas from the surrounding villages hence, it is not mandatory that this population of 85 animals will be in Pai forest all the times and there might be local migrations of these animals as these animals are facing a severe threat from local villagers through their hunting dogs. Thus, mostly this animal feeds in surrounding agricultural lands of the forest while seek refuge in the forest.

3.1.5.3 Population of Small Indian civet

Image 3 – Consultant holding a civet

Image 4 – Released Civet cat

A male small Indian civet was trapped accidentally in the house of Mr. Mohammad Rajab resident of Sarkaari Khooh, a village near Pai forest when it entered the house in search of poultry during early night. This rare animal was released in the forest on 20 June 2007 during the survey. Before releasing this animal to the wild in Pai forest, its measurements were taken that were; head length 40 cm, body length 10 cm and tail measured 33 cm. A female with 3 kittens was also seen in the same locality by Mr. Mohammad Rajab, resident of Sarkari Khooh during April 2007. Similarly one animal was observed in Pai forest in compartment No. 40 in May 2007 by Mr. Mohammad Asghar, wild life Inspector Sindh Wildlife Department. One animal was found dead on the road near Pai forest in February 2007. Based on interviews from local villagers and direct and indirect evidences in the forest, the population of Small Indian civet or Rasse (*Viverricula indica*) was estimated as 5 – 7 animals.

3.1.5.4 Population of Asiatic jackal

Population of Asiatic jackal was estimated as 40 animals in the forest. This estimation was mainly based on records of howling of five different groups of jackals in different compartments of the forest (Compartment No. 8, 37, 72, 84 and 127). The howling voices were recorded by three different survey teams while conducting night surveys on 25 June 2007. Records of howling are given in the table 4 below. Four different animals were observed directly in three different compartments (Compartment No. 33, 84 and 128) while searching hog deer early in the morning and two animals were observed directly in compartment No. 53 and 57 in the evening.

Table 11 – Records of jackals in Pai forest

Group No.	Compartment No.	Estimated animals
1	8	07
2	37	05
3	72	09
4	84	11
5	127	08
	Total	**40**

3.1.5.5 Population of Jungle cat and Bengal fox

Populations of Jungle cat and Bengal fox were estimated as three and five animals respectively in the forest. These estimates were based on the interviews of the locals as well as the wildlife watchers from Sindh Wildlife Department and forest guards from Sindh Forest Department.

3.1.5.6 Population of Small Indian mongoose and Grey mongoose

Three different teams (team A, team B and team C) that traveled through the forest along a predetermined route to observe and count the fresh tracks of Hog deer and wild boar, also recorded the direct sightings of the two species of mongooses. These teams walked across the compartments wherever possible while in other cases they searched the boundaries of the compartments to observe the animals. Each of these three teams searched along 4 km line with an approximate width of the transect 60 m. Number of individuals of small mongoose and grey mongoose recorded during three different transects are given in **Table 12** below.

Table 12 – Observation records of Small Indian mongoose and Grey mongoose

S.no	Transect Number	No. of Small Mongoose observed	No. of Grey Mongoose observed
1	A	1	1
2	B	1	0
3	C	1	1
Total		**3**	**2**

The population of both the species of mongoose in the forest was calculated by applying the formula:

$$P = AZ / 2XY$$

Where:

P = population
A = total area of study
Z = number of animals flushed
Y = average flushing distance
X = length of strip

Population of Small Indian mongoose: The population of small Indian mongoose has been calculated by the following figures:

A = total area of study	= 19.327 km²
Z = number of animals flushed	= 3
Y = average flushing distance	= 60 m = 0.06 km
X = length of strip	= 4 x 3 = 12 km

P = AZ / 2XY

P = 19.327 x 3 / 2 x 12 x 0.06

P = 57.981 / 1.44

P = 40.26 = 40 animals

Population of Grey mongoose: The population of Grey mongoose has been calculated by the following figures:

A = total area of study = 19.327 km²
Z = number of animals flushed = 2
Y = average flushing distance = 60 m = 0.06 km
X = length of strip = 4 x 3 = 12 km

P = AZ / 2XY

P = 19.327 x 2 / 2 x 12 x 0.06

P = 38.654 / 1.44

P = 26.84 = 27 animals

3.1.6 Relative abundance

Relative abundance of different mammalian species found in the forest was calculated using the formula;

RA = n / N

Where;

n = number of individuals of i group
N = number of total individuals of all the groups

Relative abundance of mammalian species found in Pai Forest is given in **Table 13**

Table 13 – Relative abundance of mammalian species in Pai Forest

Sr. No.	Species	Estimated Populations	Relative Abundance
1	Hog deer	19	0.084
2	Indian wild boar	85	0.377
3	Small Indian civet	6	0.026
4	Asiatic jackal	40	0.177
5	Jungle cat	3	0.013
6	Bengal fox	5	0.022
7	Small Indian mongoose	40	0.177
8	Grey mongoose	27	0.120

3.1.7 Threats and recommendations

3.1.7.1 Threats

Some of the major threats to large mammals in Pai forest due to anthropogenic activities are discussed below.

- **Wood cutting:** Wood cutting is a common practice in the forest. One can daily observe a number of local people cutting and collecting wood in various compartments. Similarly, livestock grazing in the forest and as a result to such activities, frequent and continuous movements of human in the forest is causing continuous disturbance in the habitat of Hog deer and thus posing a threat to the hog deer population. This kind of disturbance in the habitat of Hog deer also supports the view of constant movement of a limited population of Hog deer in the forest.

- **Habitat degradation:** Besides other factors, the partridge hunting areas are being increased by cutting forest which is used for cultivation. These cultivated areas are basically to support partridge population in the Pai Forest Game Reserve.

- **Mortalities associated with habitat loss:** Hog deer is particularly associated with the riverine habitat of *Tamarix* and *Saccharum*. Due to embankment on River Indus, Pai Forest is not a riverine forest now and the habitat of the Hog deer is now limited to a forest with no ground vegetation. There are cultivated lands all around the Pai forest and disturbances in the forest such as shooting of partridges, hunting of wild boar with hunting dogs etc. that cause the dispersal of the animals to the surrounding areas where they face serious hunting pressures and mortalities due to road accidents.

- **Dryness of the forest:** Dryness of the forest due to lack of water in most parts of the forest is another threat. The existing tube wells are used for irrigating cotton, wheat and mustard crops inside the forest. The crops are cultivated for increasing food availability and shelter for partridges for which shooting permits are issued. Aridity in the area is also increasing due to plantation of fast growing *Eucalyptus* tree in the degraded areas.

- **Hunting with dogs in the forest:** The local influential people are fond of keeping dogs which are used for hunting wild boar and Hog deer. During the present study, evidence was collected when hunting dogs caused deadly injuries to Hog deer's. According to locals, this is an easy way to hunt Hog deer. Hence the presence of hunting dogs in adjacent villages of the forest is a serious threat for Hog deer.

- **Road Accidents:** Due to the absence of boundary walls or a fence, when Hog deer crosses the boundaries of the forest, it gets trapped by local villagers and sometimes, gets killed while running past the highway. One such evidence was also recorded during 2006 as shown in the Fig. 57.

Image 5 – Hog deer accidentally killed on road near Pai Forest

Image 6 – Hog deer deadly wounded by hunting dogs

- **Partridge hunting;** Pai forest is a game reserve for partridge hunting. The hunting of partridges with guns disturbance to the animals in their habitat.

- **Food Competition with livestock:** Hog deer has very limited grazing grounds in the forest. Due to hunting pressures from surrounding areas, Hog deer cannot forage out side the forest. Livestock grazing in the forest poses a severe food competition with Hog deer.

- **Disease Transmission from livestock:** There is very little awareness about vaccination in livestock among the livestock owners in the area. Affected animals sharing the same grazing grounds may transmit

3.1.7.2 Recommendations

- **Hog deer breeding in vacant enclosures:** The abandoned enclosures constructed in compartment No. 128 at N 26º 05 .717 and E 68º 16 .208 by SWD for partridges and hog deer breeding may be made functional and Hog deer, the key mammalian species of the forest, should be reared here. This could also help promoting eco-tourism at this programme site and the visitors could see the Hog deer in the forest that otherwise is very difficult.

- **Fencing of Pai forest:** There should be the fencing of Pai forest especially eastern side along the highway. In this way the existing population of Hog deer will be more secure as this is the area where the main hunting pressure exists. Secondly, it will help in controlling road accidents of Hog deer, reducing illegal wood cutting and movements of Hog deer from Pai forest to neighboring agricultural fields.

- **Incentives for wildlife watchers:** There should be some incentives for wildlife watchers who conserve Hog deer through their round the clock efforts.

- **Replacement of exotic plant species with indigenous species:** Exotic species such as *Mesquite* and *Eucalyptus* should be checked and controlled and gradually replaced with local species such as *Acacia nilotica* (Babul), *Salvadora persica* (Khabbar), *Salvadora oleoides*, *Acacia senegal* etc. to add more diversity in the plantation as well as better shelter and refuge for wildlife. Moreover, plantation of some fruit trees

near the tube wells, Forest Guest House and Forest Colony may attract various birds and hence an attraction for the visitors.

- **Develop eco-tourism:** Construction of a proper entrance gate with sign board on Highway as well as the erection of information sign boards at entrance and other important points, providing information about Wildlife Laws etc will add to the Forest and help developing eco-tourism and awareness among general public.

- **Continuous water supply for the forest:** The existing tube wells are being used only for crop cultivation purposes in partridge beat areas. There is need to restore the sanctioned irrigation water supply for the forest through Irrigation Department. This will help maintaining the forest and ultimately the habitat.

- **Declare Pai Forest as Wildlife Sanctuary:** Although Pai forest does not offer an ideal habitat to Hog deer yet it is providing refuge and shelter to the only remaining population of Hog deer in lower Indus other than at Chotiari. Secondly, Hog deer is the key mammalian species in the forest and basis for the selection of Pai forest as one of the programme sites. Therefore, the status of the forest as Game Reserve should be changed to a Wildlife Sanctuary for conserving Hog deer.

- **Develop coordination between Forest and Wildlife Departments:** There is a need to ensure better coordination between Sindh Forest and Sindh Wildlife Departments in order to maintain this forest and existing wildlife on sustainable bases.

- **Community Mobilization:** Communities around the forest should be mobilized for biodiversity conservation and outreach programme should be established for them. The options of engaging local communities in forest and wildlife conservation may be explored.

- **Conserve habitat through alternate energy resources:** To address the fuel wood requirements of neighboring communities other avenues must be explored such as initiation of dialogue with Sui Southern Gas to provide natural gas connection to at least big villages. Biogas plants can also be introduced as the most economical source of energy. Another option could be to raise fuel wood lots at the nearby Mari Riverine forest area which is totally devoid of trees and area has been leased out to farming community. Fuel wood lot on this area would be successful if local communities are involved in watch and ward, planting and after-care operations. A scheme of wood sharing after 6-year rotation could be worked out involving Nazims of concerned Union Councils and Forest Department.

3.2 Large Mammals (Keti Shah)

3.2.1 Sampling Sites

Different sites in both the parts of Keti Shah Forest were searched to locate the existing large mammals and the GPS coordinates at different locations were recorded. Different sampling sites and distribution of large mammals around Keti Shah are given in **Map 5**. GPS coordinates were taken at different locations in Keti Shah Forest during summer and winter surveys and are given in the annexure document.

Map 5 – showing the sampling points for large mammals at Keti Bunder

3.2.2 Species identified

A total of 22 animals of 11 different large and medium sized mammalian species, belonging to three orders (Carnivora, Artiodactyla and Cetacea) were recorded from the study area. Mammals recorded from Keti Shah Forest are given in **Table 14**

Table 14 – Large mammals recorded from Keti Shah

S.No	Common Name	Zoological Name	Order	No. recorded
1	Asiatic jackal	*Canis aureus*	Carnivora	2
2	Jungle cat	*Felis chaus*	Carnivora	1
3	Bengal fox	*Vulpes bengalensis*	Carnivora	-
4	Desert fox	*Vulpes vulpes pusilla*	Carnivora	-
5	Indian otter	*Lutrogale perspicillata*	Carnivora	-
6	Small Indian mongoose	*Herpestes javanicus*	Carnivora	4
7	Grey mongoose	*Herpestes edwardsi*	Carnivora	2
8	Small Indian civet	*Viverricula indica*	Carnivora	-
9	Hog deer	*Axis porcinus*	Artiodactyla	-
10	Indian wild boar	*Sus scrofa*	Artiodactyla	-
11	Indus dolphin	*Platanista minor*	Cetacea	13

3.2.3 Observation records

Out of 11 species of large mammals, recorded from the study area, five were observed directly while the remaining six 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 mammals are given in **Table 15.**

Table 15 – Observation records of different mammalian species at Keti Shah

S.no	Species	Direct Obs.	Indirect Observations		
			Tracks	fecal material	Interviews with Locals
1	Asiatic jackal	✓	-	-	✓
2	Jungle cat	✓	-	-	✓
3	Bengal fox	-	-	-	✓
4	Desert fox	-	-	-	✓
5	Indian otter	-	✓	-	✓
6	Small Indian mongoose	✓	-	-	✓
7	Grey mongoose	✓	-	-	✓
8	Small Indian civet	-	-	-	✓
9	Hog deer	-	✓	✓	✓
10	Indian wild boar	-	✓	-	✓
11	Indus dolphin	✓	-	-	✓

3.2.4 Conservation status of different mammalian species

Out of the 11 recorded species, one is Endangered (E), one is Vulnerable (VU), 5 Near Threatened (NT) and 4 Least Concern (LC) according to the IUCN Red List of Pakistan Mammals 2005. Jungle cat, small Indian mongoose and Small Indian civet are enlisted as Least Concern (LC) in IUCN international Red List 2006. Jungle cat, Indian otter, Small Indian civet, Hog deer and Indus dolphin are protected (P) in Sindh. Jungle cat is listed in Appendix II while Hog deer and Indus dolphin are enlisted in Appendix I of the CITES category 2007. The conservation status of mammalian species found at Keti Shah is given in **Table 16**.

Table 16 – Conservation status of mammals found at Keti Shah Forest

Sr. No.	Mammalian Species Recorded from Keti Shah	IUCN International Red List 2006	IUCN Pakistan Red List 2005	Sindh Wildlife Protection Ordinance 1972	CITES Category 2007
1	Asiatic jackal	-	NT	-	-
2	Jungle cat	LC	LC	P	Appendix II
3	Bengal fox	-	NT	-	-
4	Desert fox	-	NT	-	-
5	Indian otter	-	NT	P	-
6	Small Indian mongoose	LC	LC	-	-
7	Grey mongoose	-	LC	-	-
8	Small Indian civet	LC	NT	P	-
9	Hog deer	-	VU	P	Appendix I
10	Indian wild boar	-	LC	-	-
11	Indus dolphin	-	E	P	Appendix I
Legend: E = Endangered, VU = Vulnerable, NT = Near Threatened, LC = Least Concern, P = Protected					

3.2.5 Population estimations

In a short visit of five days, an effort was made to estimate the populations of two aquatic mammal i.e. Indian otter (*Lutrogale perspicillata*) and Indus dolphin (*Platanista minor*).

3.2.5.1 Population of Indian otter

Population of Indian otter was estimated using the tracks count technique. While traveling on motor boat from one part of the forest to the other through the river, the foot prints of Indian otter were observed at three different locations. After observing carefully, and differentiating between the foot prints of different animals on the basis of size, the number of fresh foot prints at each location was counted that reflected the number of individuals existing at each location. A total of 11 Indian otter were estimated at Keti Shah Riverine Forest. The observation records of tracks of Indian otter are given in **Table 17.**

Table 17 – Observation records of tracks of Indian otter

Sr. No.	Location	No. of different Tracks	No. of Animals
1	N 27º 46' .299", E 68º 55' .442"	06	06
2	N 27º 48' .068", E 68º 54' .054"	02	02
3	N 27º 46' .785", E 68º 55' .183"	03	03
	Estimated population of Indian otter	**11**	**11**

3.2.5.2 Population of Indus dolphin

For the estimation of Indus dolphin's population at Keti Shah, a transect was taken on a motor boat driven at a speed of 5 km/h along that part of the river lying between the two parts of the forest. The length of the transect was about 4 km while the width was around 200 m on either side of the boat. Two observers and one recorder worked simultaneously and each observer watched along 90º in an arc sweeping one quarter on front view from the boat. Digital camera was used for still photography to record the evidences. The estimated population of Indus dolphin based on direct sightings was 13 animals.

Image 7 – Tracks of Indian otter

Image 8 – Indus dolphin at Keti Shah

Table 18 – Sighting records of Indus dolphin at Keti Shah

Sr. No.	Location	No. of Animals Observed
1	N 27º 46' .299", E 68º 55' .442"	05
2	N 27º 47' .351", E 68º 54' .772"	04
3	N 27º 46' .785", E 68º 55' .183"	04
	Estimated population of Indus dolphin	13

3.2.6 Field notes

A summary of the individual species of large and medium sized mammals recorded from Keti Shah is given below.

Asiatic jackal

Asiatic jackal is a commonly found mammalian species in Keti Shah. Occasionally it preys upon poultry and lambs and kids so the local people dislike this animal. Jackal is not facing any serious threat in Keti Shah Forest whereas some people consider it a problem species.

Jungle cat

Jungle cat is considered as a problem species in the study area as it attacks the poultry but even then it is not facing any serious threat.

Bengal fox

This species is not facing any serious threats in the area. During the present survey its existence in the study area was confirmed after interviewing different local people and forest guards.

Desert fox

Desert fox is rarely seen in the area as it has been persecuted in the past for its fur. However, this species is not facing any serious threats in the area.

Indian Otter

Indian otter was observed at three different locations in Keti Shah Forest i.e. in compartment No. J - 8 at N 27º 46' .785", E 68º 55' .183", compartment No. L - 6 at N 27º 48' .068", E 68º 54' .054" and in

	compartment No. L - 6 at N 27º 46' .299", E 68º 55' .442". Fishermen and other local residents revealed during interviews that the otters were occasionally observed near thickets along river banks. The main reason for a rapid decline in otter population is demand of its skin and misconception about the medicinal value of its skin and fat. Auyorvedic practitioners consider the cushions made of otter skin as a remedy to piles, and a cap made of otter skin as a cure for margarine.
Small Indian mongoose	During the present survey two animals were observed at two different locations in the study area.
Grey mongoose	This species is not facing any serious threats in the study area and common found according to the local residents.
Small Indian civet	During the present survey, this animal was recorded from Keti Shah on the basis of indirect evidences through interviews from local people. This animal is not facing any threat in the study area.
Hog deer	Hog Deer is hunted in the study area for meat purposes. Special traps for hog deer hunting in Keti Shah were observed that remain set throughout the year. During floods, Hog deer while finding some refuge in the surrounding areas when come close to human habitations, it being Halal animal (edible by Muslims), face hunting pressures from locals. Wild boar and hog deer usually share the same habitat but in Keti Shah, the evidences of wild boar were numerous in the form of dug soil but very few signs of Hog deer were observed that also indicate the extent of hunting pressure on Hog deer in Keti Shah.
Wild boar	Wild boar is the commonly found species in the study area. Being mainly herbivorous, it was located at night near agricultural fields. Evidences of its occurrence like destruction in agriculture fields, uprooted plants and foot prints were also observed in different areas in Keti Shah. This species is not facing any threat as it is considered an unclean animal and the locals dislike its presence. It is the only species of ungulates which is common and neither is it protected nor is it hunted and it does not have any natural predator as well.

Indus dolphin	Thirteen dolphins were observed in 4 Km area of the River Indus while boating from one part of the forest to the other. People don't hunt this animal in the study area hence this animal is not facing any threat in the study area. WWF Pakistan with the collaboration of Sindh Wildlife Department is effectively undertaking conservation programme for this species in River Indus.

3.2.7 Threats and recommendations

3.2.7.1 Threats

- **Natural Threats:** Habitat loss in Keti Shah Forest due to floods in River Indus is a natural phenomenon which damages the populations of small mammals like rodents, some medium sized carnivores and also the large mammals like Hog deer by forcing them to migrate to other, less secure areas;

- **Hunting Pressure:** Floods are a natural threat to the existing mammalian fauna and cause the dispersal of mammals especially the Hog deer. During floods, hog deer look for shelter in the surrounding areas however when they come across human dwellings face hunting pressures from locals. Wild boar and hog deer usually share the same habitat but in Keti Shah the evidence of wild boar were numerous in the form of dug soil but very few signs of Hog deer were observed indicating the extent of hunting pressure on hog deer in Keti Shah.

Image 9 – Forest fire and illegal wood cutting at Keti Shah Forest

Image 10 – Illegal wood cutting at Keti Shah Forest

- **Improper Implementation of wildlife laws:** Due to the prevailing situation in Keti Shah, Sindh Forest and Sindh Wildlife Departments do not have effective control on the area. Under such circumstances, the inhabitants of the area trap and hunt Hog deer with special and permanently set traps; posing a continuous threat for the Hog deer in the Keti Shah. Thus Hog deer is striving for its survival in Keti Shah.

- **Wood cutting:** Wood cutting or logging of trees in the forest is a common practice that also contributes to the habitat degradation.

- **Law and order situation:** As the forest has a thick vegetation cover and no vehicle can move in the forest, some dacoits and other unwanted

characters use this forest as a refuge. Their encounter with law enforcement agencies is also a common practice that also create disturbance for the wildlife.

3.2.7.2 Recommendations

- **Involvement of local communities:** Local communities have some concerns regarding wildlife species political environment of the area and socio-economical conditions in the area. Therefore, Sindh Wildlife Department, Sindh Forest Department and other conservation organizations like *Indus for All Programme* etc. should develop close relations with the local communities. The involvement of local communities of the study area will ensure the conservation and management of mammalian wildlife on sustainable basis.

  Raising awareness: There should be an effective initiative to protect habitat degradation and hunting of Hog deer in particular. Intensive environmental education, widespread project awareness, continuous monitoring and forest protection are equally important for conservation of mammalian species.

- **Incentives for the local residents:** Residents of the Keti Shah Forest are living in isolation with no basic facilities like Basic Health Unit, Primary school, electricity etc. These people should be provided with at least a Basic Health Unit and a Primary school because these are the first things to do and then the conservation of wildlife in the area.

- **Promotion of indigenous income resources:** Every household in the forest holds a good number of livestock like 50 to 200. There should be some incentives for the locals to promote livestock products. This will ultimately reduce their business of fuel wood and hence the wood cutting in the forest could be minimized that will ultimately help in habitat conservation.

Image 11 – Use of natural resources at Keti Shah

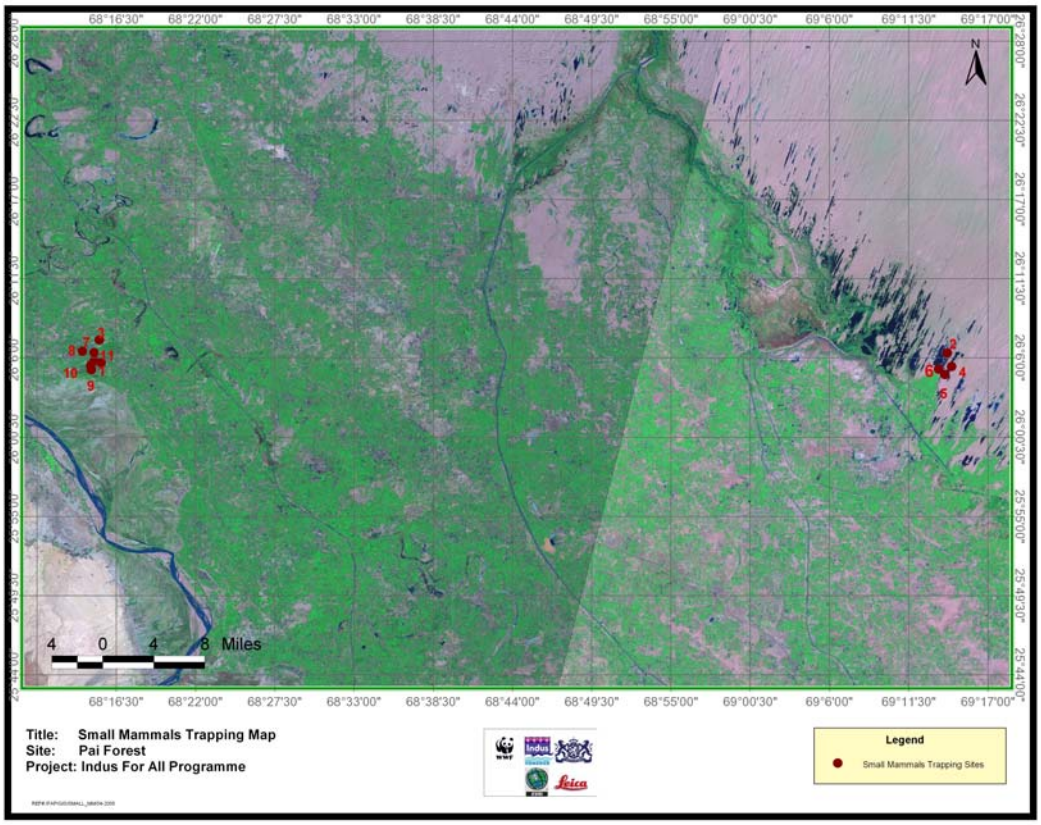
Image 12 – Inundation of plantation at Pai Forest

3.3 Small Mammals (Pai Forest)

3.3.1 Sampling locations

Map 6 shows the sampling locations for small mammals at Pai Forest. Further details of the sampling points can be found in the annexure document.

Map 6 – Showing trapping locations for small mammals at Pai Forest



3.3.2 Species account

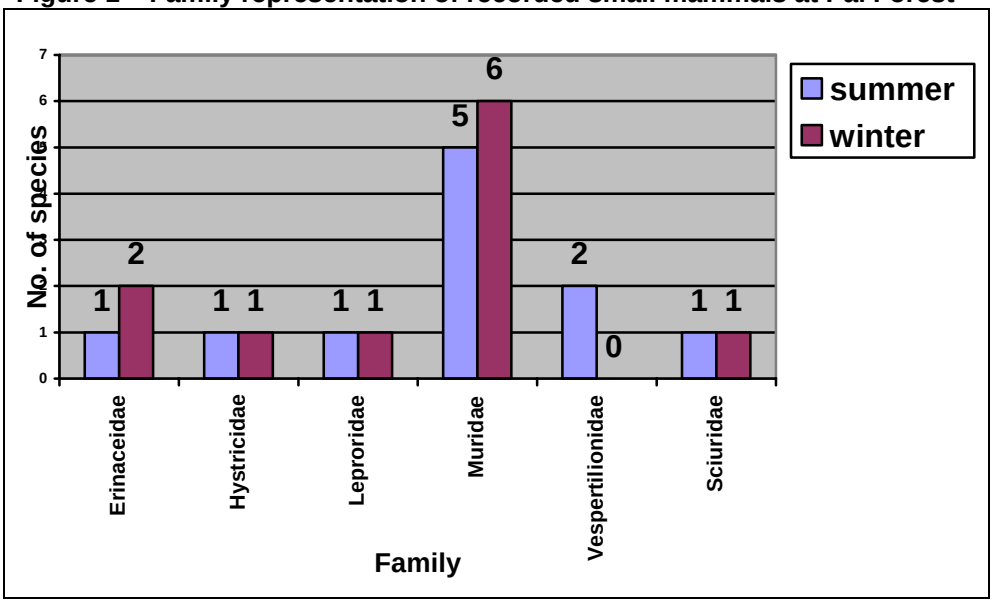
A total of 14 species were recorded from Pai Forest and its surroundings, out of which 11 species were recorded in summer and 11 species in winter. The 14 species belong to 5 orders (Rodentia, *Insectivora, Lagamorpha and Chiroptera*) and 6 families. **Table 19** gives an account of the species recorded at Pai Forest along with their conservation status, feeding habits and activity habits.

Table 19 – Total species recorded at Pai Forest along with conservation status, feeding habits and activity habits

	Scientific name	English Name	Feeding Habit	Behavior	Status	Summer	Winter
1	*Bandicota bengalensis*	Sindh Rice Rat	GRN	NC	C	+	+
2	*Funambulus pennantii*	Palm Squirrel	GRN	DR	C	+	+
3	*Golunda ellioti*	Indian bush rat	GRN	NC	LC	+	-
4	*Hemiechinus collaris*	Long-eared Hedgehog	OMV	NC	LC	+	+
5	*Hystrix indica*	Indian crested porcupine	HRB	NC	C	+	+
6	*Lepus nigricolis*	Desert hare	HRB	NC	C	+	+
7	*Millardia gleadwi*	Sand	GRN	NC	LC	-	+

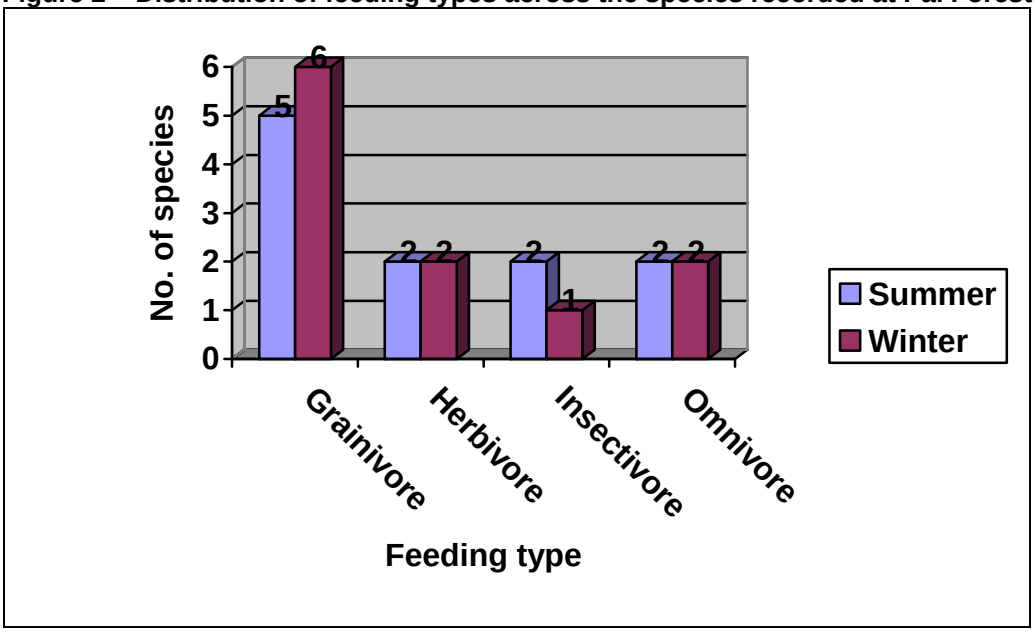
		coloured rat					
8	*Millardia meltada*	Soft-furred field rat	GRN	NC	LC	-	+
9	*Mus musculus*	House mouse	GRN	NC	C	+	+
10	*Paraechinus micropus*	Indian Hedgehog	INS	NC	C	-	+
11	*Pipistrellus kuhlii*	Kuhls' bat	INS	NC	C	+	-
12	*Rattus rattus*	Common Rat	OMV	NC	C	+	+
13	*Scotophilus heathii*	Common yellow-bellied bat	INS	NC	LC	+	-
14	*Tatera indica*	Indian Gerbil	GRN	NC	C	+	+

Figure 1 – Family representation of recorded small mammals at Pai Forest



As with most sites the family Muridae was the most commonly recorded with the remaining five families having one to two representations. During the survey the population of *porcupine* was observed to be greater than any of the small mammal species. Similarly, *Tatera indica, Hemiechinus collaris,* marks and live specimen observed, during nocturnal spot-light search. *Lepus nigricolis* were observed in C-42, C- 52 and sighted *Felis chaus* in C- 42*, Bandicota bengalensis w*as sighted near Goth Palio Bhutto in rice field, when reaped bundle of rice were turned for searching of rodents. Porcupine tracks and shed spines were observed from cultivated areas of Pai forest.

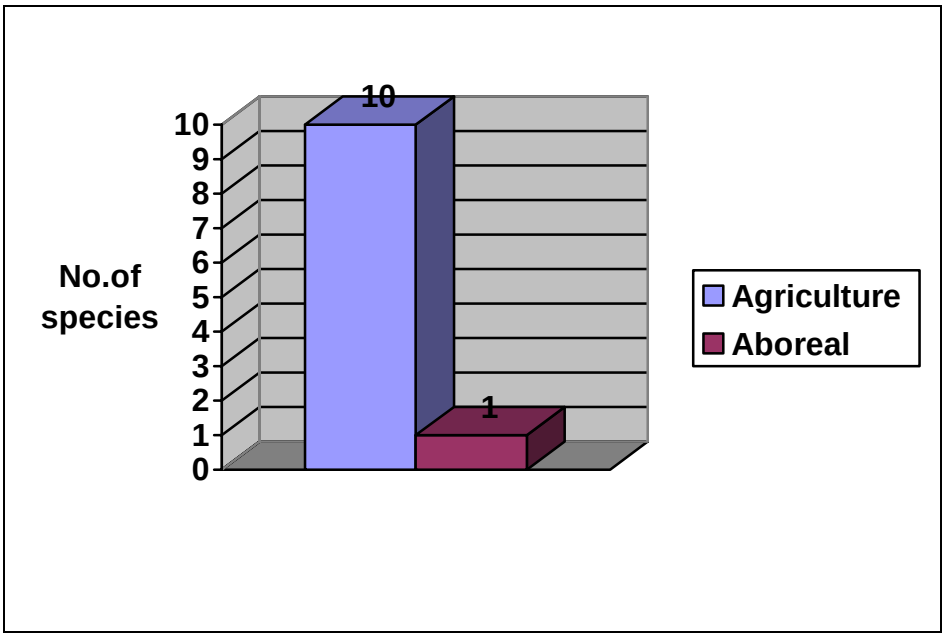
Figure 2 – Distribution of feeding types across the species recorded at Pai Forest



3.3.3 Feeding habits

Granivore were the most the most common feeding habit with equal distribution from insectivores, omnivores and herbivores. There was little change over season as shown in **Figure 3**.

Figure 3 – Number of species recorded from main habitat types at Pai Forest

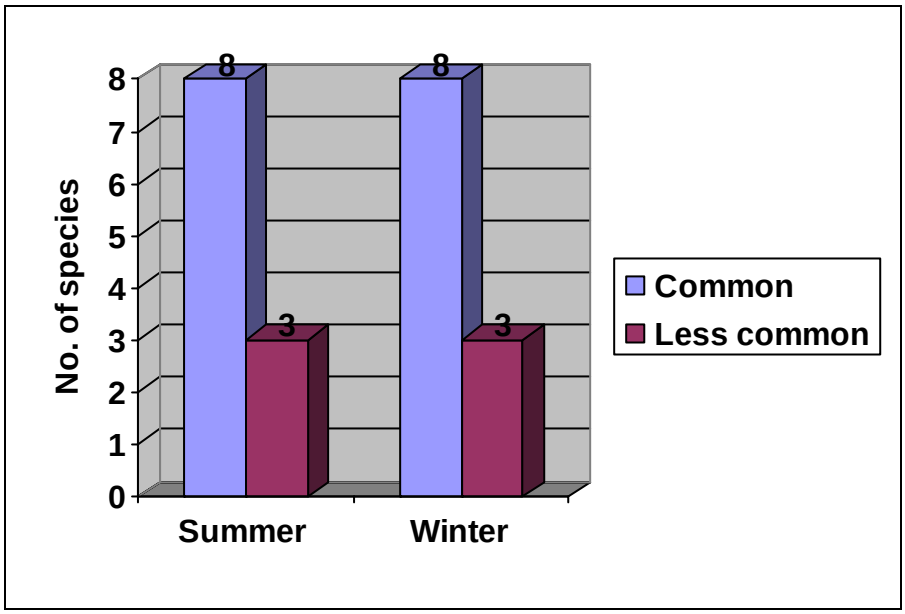


3.3.4 Habitat

The forest has five major species of plants viz: *Prosopis cineraria* (very common), *Acacia nilotica* (common), *Eucalyptus camaldulensis* (common on north and NE sides), *Tamarix indica* (common) *and Tamarix aphylla* (occasional). Other plants of the area include *Salvadora oleoidus, Salvadora persica, Calotropis procera, Zizyphus nummularia and Capparis deciduas.* Most of the small mammal species were recorded from agriculture land except one bat species which was observed

roosting (shown **in Figure 3** above) As with most sites, common species made up more than 60% of the recorded (**Figure 4** below) with the remaining species falling under the less common category.

Figure 4 – Distribution of small mammal status over the species and season at Pai Forest



3.3.5 Threats and recommendations

3.3.5.1 Threats

The ecosystem in the Pai forest has been disturbed and various components of the ecosystem are either lacking or they are in a state of deterioration. There are a number of factors for this stress on the ecosystem. The main problems faced by this ecosystem are discussed below:

- Overgrazing seems a severe problem in the Pai forest which can potentially have an affect on the herbivore and granivore small mammal species in terms of food source. Additionally heavy grazing pressure which results in a reduction in ground foliage can have an affect on the breeding success of small mammals as well as increase the change of predation

- Extensive farming and application of agro-chemicals are contaminating the agriculture land and associated micro-habitats such as marginal lands in the area. Such contamination is known to directly and directly impact small mammal population through direct poisoning and reduction of food-source, especially in the case of insectivores;

3.3.5.2 Recommendations:

- Farmers should be made aware about the importance of small mammal as natural pest controllers and be given instructions on wise-use of pesticides and other agro-chemicals on farmed land;

- The local communities should be educated about the importance of wild fauna like amphibian, reptilian and small mammals especially in the forest ecosystem in close coordination with local community, through frequent

visits, exposure visits/ tours for representatives of Keti Shah to community protected areas;

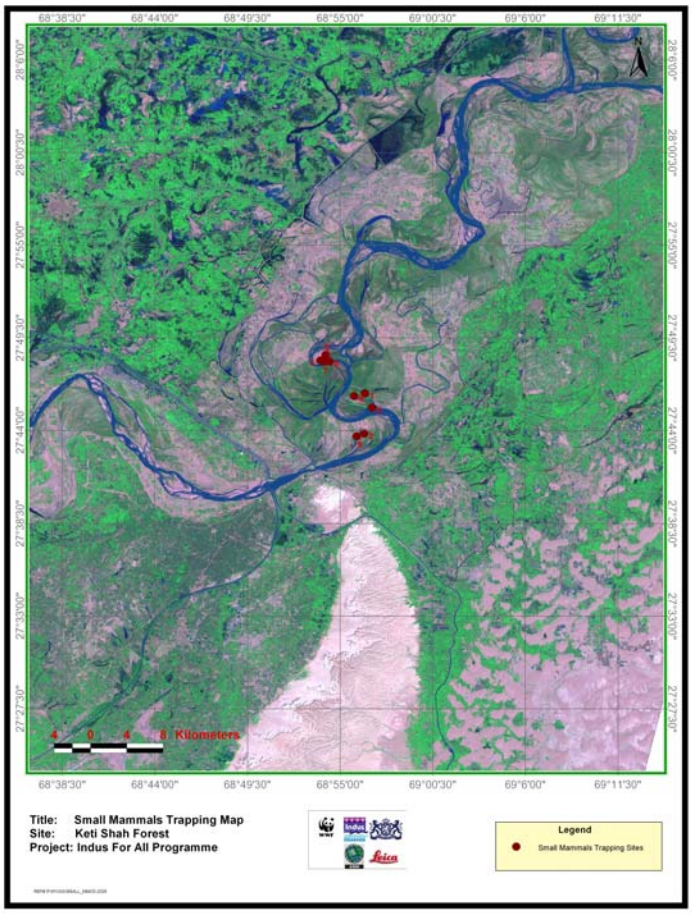
- Awareness raising activities organized for the stakeholders other then Keti Shah, for citizens of Sukkur by workshops, pamphlets and brochures.

3.4 Small Mammals (Keti Shah)

3.4.1 Sample locations

Map 7 shows the trapping points for small mammals from Keti Shah. Further details of the sampling points can be found in the annexure document.

Map 7 – Showing trapping locations for small mammals at Keti Shah



3.4.2 Species account

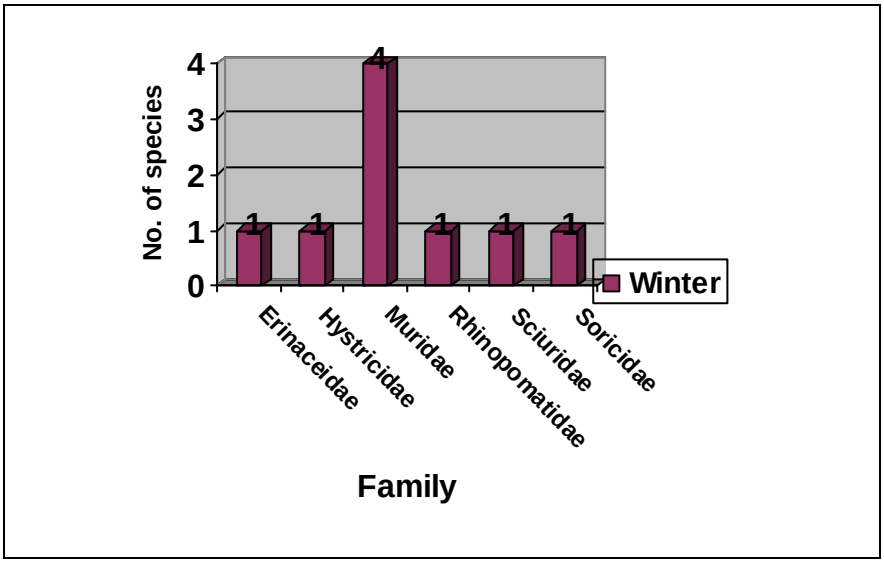
A total of 9 species were recorded from Keti Shah and its surroundings, out of which all were recorded in summer. The 14 species belong to 3 orders (Rodentia, Insectivora and Chiroptera) and 6 families. **Table 20** gives an account of the species recorded at Keti Shah along with their conservation status, feeding habits and activity habits.

Table 20 – Total species recorded at Keti Shah along with conservation status, feeding habits and activity habits

S.no	Scientific Name	English Name	Feeding Habit	Behavior	Status	Summer	Winter
1	*Bandicota bengalensis*	Sindh Rice Rat	GRN	NC	C	-	+
2	*Funambulus pennantii*	Palm Squirrel	GRN	DR	C	-	+
3	*Hystrix indica*	Indian crested porcupine	HRB	NC	C	-	+
4	*Mus musculus*	House mouse	GRN	NC	C	-	+
5	*Paraechinus micropus*	Indian Hedgehog	INS	NC	C	-	+
6	*Rattus rattus*	Common Rat	OMV	NC	C	-	+
7	*Rhinopoma microphyllum*	Large mouse tailed bat	INS	NC	LC	-	+
8	*Suncus murinus*	House shrew	INS	NC	C	-	+
9	*Tatera indica*	Indian Gerbil	GRN	NC	C	-	+

Keti Shah forest is one of the low lying riverine forests predominated by *Acacia nilotica*. Other terrestrial vegetation includes *Tamarix dioica, T. aphylla, Prosopis juliflora, Alhaji maurorum* and *Populus euphratica*. Aquatic vegetation comprises of *Saccharum spontaneum, S. bengalense, Typha angustata, T. latifolia, Phragmites karka* and *Persicaria orientalis*. The forest is divided in patches by the main river, bye-rivers and several seasonal and permanent river channels/depressions and inundated under water in summer from June to August. During flood season, wild animals migrate to high-lying areas of adjoining forests. This seasonal habitat fluctuation of habitat disturbs the burrowing animals specially reptiles and small mammals.

Figure 5 – Family representation of recorded small mammals at Keti Shah



As shown in **Figure 5** above, most of the species trapped belonged to the Muridae family with the remaining five families having one representative in each. The feeding habits of the species recorded at Keti Shah were also consistent with other sites e.g. granivores were predominate followed by insectivores with herbivores and omnivores being sub-dominant (**Figure 6**)

Figure 6 – Distribution of feeding types across the species recorded at Keti Shah

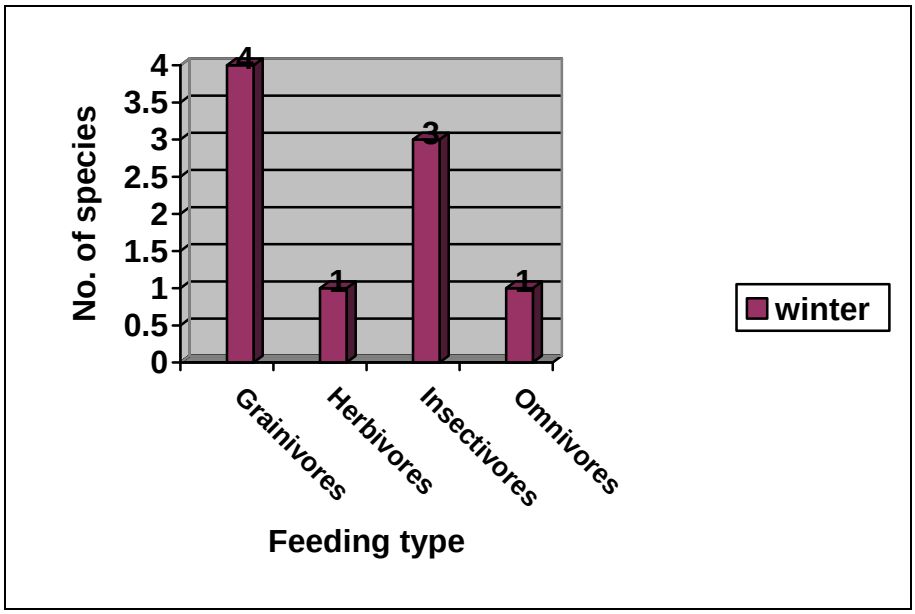
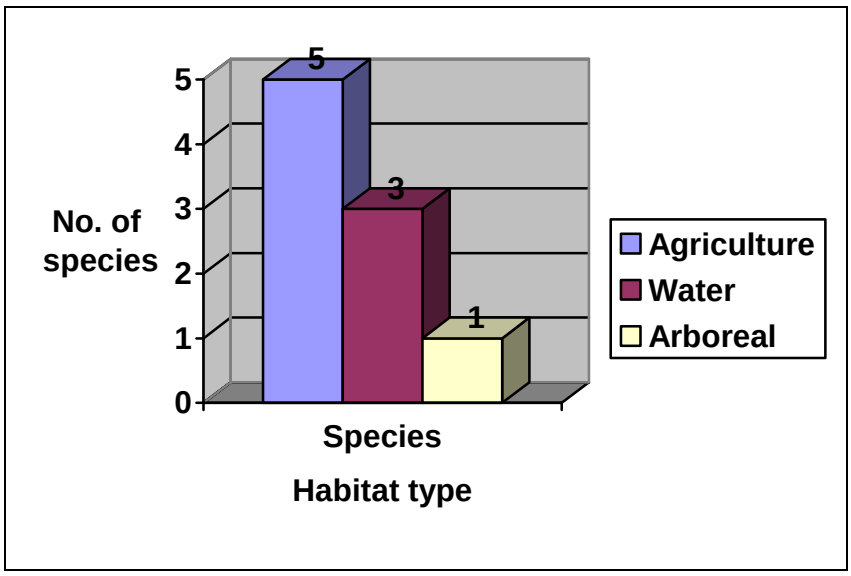


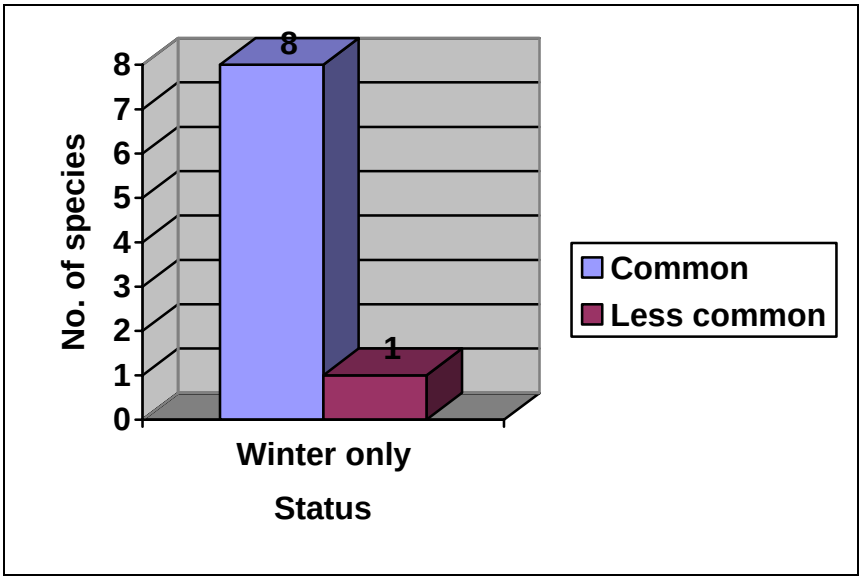
Figure 7 – Number of species recorded from main habitat types at Keti Shah



Distribution of species over habitats was predominately towards the agriculture habitats followed by water habitats such as canals. One bat species was observed roosting, marked here as arboreal (**Figure 7**)

Most of the species observed at Keti Shah were common with only one less common species being recorded (**Figure 8**)

Figure 8 – Distribution of small mammal status over species at Keti Shah



3.4.3 Threats and recommendations

3.4.3.1 Threats

- Being a typical example of riverine forest at Keti Shah, seasonal flooding in a serious threat, albeit a natural one to small mammals.

- Overgrazing seems to be a severe problem in the Keti Shah forest which can potentially have an affect on the herbivore and granivore small mammal species in terms of food source. Additionally heavy grazing pressure which results in a reduction in ground foliage can have an affect on the breeding success of small mammals as well as increase the change of predation

- Extensive farming and application of agro-chemicals are contaminating the agriculture land and associated micro-habitats such as marginal lands in the area. Such contamination is known to directly and directly impact small mammal population through direct poisoning and reduction of food-source, especially in the case of insectivores;

4.4.3.2 Recommendation

- Farmers should be made aware about the importance of small mammal as natural pest controllers and be given instructions on wise-use of pesticides and other agro-chemicals on farmed land;

- The local communities should be educated about the importance of wild fauna like amphibian, reptilian and small mammals especially in the forest ecosystem in close coordination with local community, through frequent visits, exposure visits/ tours for representatives of Keti Shah to community protected areas

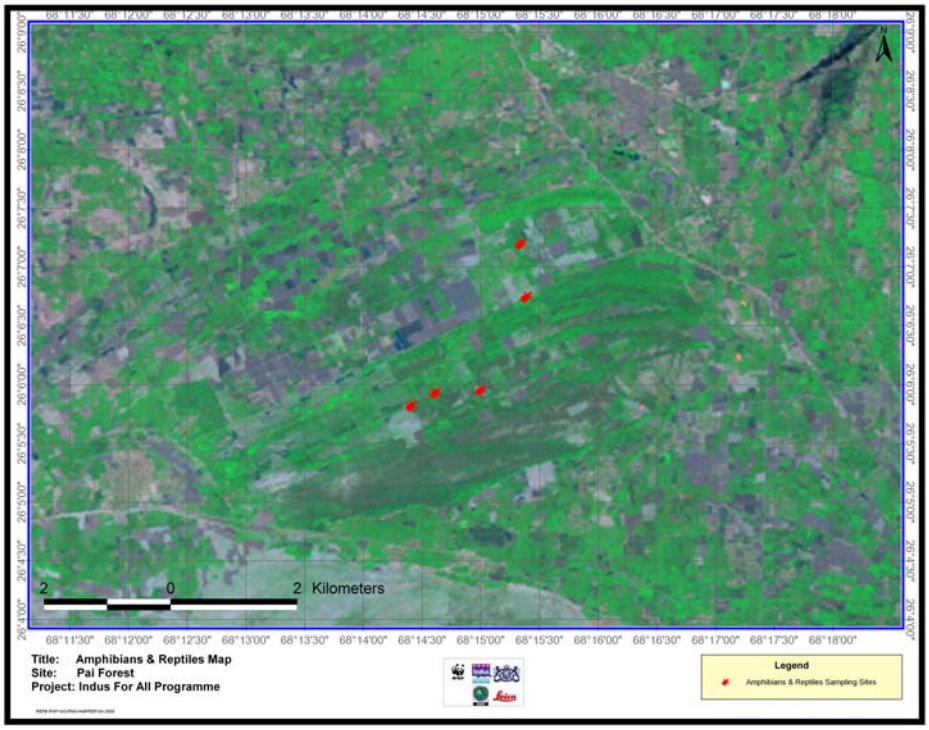
- Awareness raising activities organized for the stakeholders other then Keti Shah, for citizens of Sukkur by workshops, pamphlets and brochures.

3.5 Reptiles and amphibians (Pai Forest)

3.5.1 Sample location

Map 8 shows the location of trapping points for reptiles and amphibians from Pai Forest. Further details can be found in the annexure document.

Map 8 – Sampling points for reptile and amphibians from Pai Forest



3.5.2 Species account

during the surveys in summer 13 species of amphibians and reptiles out of 47 species possibly occurring in the area, were observed or collected by the author and his team, and the remaining were identified through the local inhabitants after thorough discussions as well as by the earlier records in the literature. The studies were repeated in winter season for the maximum likelihood of the recording of herpetiles. It resulted in the addition of 05 species of reptiles increasing the number to 18. The species collected during winter studies included a single species of gecko Cyrtopodion scaber, lacertid lizard Ophisops jerdonii, colubrid snake Platyceps v. ventromaculatus and two species of skinks Eutropis dissimilis and Eurylepis t. taeniolatus.

The amphibians are represented by three species belonging to three genera and two families. Among the reptiles, chelonians are represented by single species belonging to family Trionychidae. Lizards are the second dominant group of herpetiles, represented by 19 species belonging to 13 genera and seven families. Snakes outnumber all the groups of reptiles in the study area and are represented by 24 species belonging to 18 genera and six families.

Table 21 shows a very rich and diverse set of observations and collection of herpetiles made during the summer survey due to the active period of their lives. On the contrary pre-winter studies revealed a lower number of richness, Shannon and Margalef indices. The evenness is relatively higher in winter studies but this is not a prominent reflector of higher diversity.

Table 21 – Comparison of Amphibian and Reptilian diversity during summer and pre-winter studies at Pai forest, District Nawabshah

S. No.	Species Name	Total	Summer	Winter
1	*Bufo stomaticus*	42	39	03
2	*Euphlyctis c. cyanophlyctis*	20	13	07
3	*Hoplobatrachus tigerinus*	08	08	0
4	*Lissemys punctata andersoni*	06	06	0
5	*Eublepharis macularius*	04	04	0
6	*Uromastyx hardwickii*	07	07	0
7	*Calotes v. versicolor*	05	05	0
8	*Cyrtopodion scaber*	04	0	04
9	*Hemidactylus brookii*	06	06	0
10	*Hemidactylus flaviviridis*	26	18	08
11	*Hemidactylus leschenaultii*	07	05	02
12	*Ophisops jerdonii*	09	0	09
13	*Eurylepis t. taeniolatus*	03	0	03
14	*Eutropis dissimilis*	06	0	06
15	*Varanus bengalensis*	24	24	0
16	*Eryx conicus*	03	03	0
17	*Platyceps v. ventromaculatus*	02	0	02
18	*Echis carinatus sochureki*	09	09	0
	Total (number of individuals collected)	191	147	44

3.5.3 Species diversity

Table 22 and Figures 9 to **11** show various analysis of diversity of reptiles and amphibians recroded at Pai Forest.

Table 22 – species diversity indexes for reptiles and amphibians recorded from Pai Forest during summer and winter

S.no	Index type	Summer	Winter
1	Richness (number of species)	13	09
2	Evenness	0.7391	0.8752
3	Shannon Index	2.263	2.064
4	Margalef Index	2.405	2.114

Figure 9 – Species diversity of reptiles and amphibians at Pai Forest over summer and winter

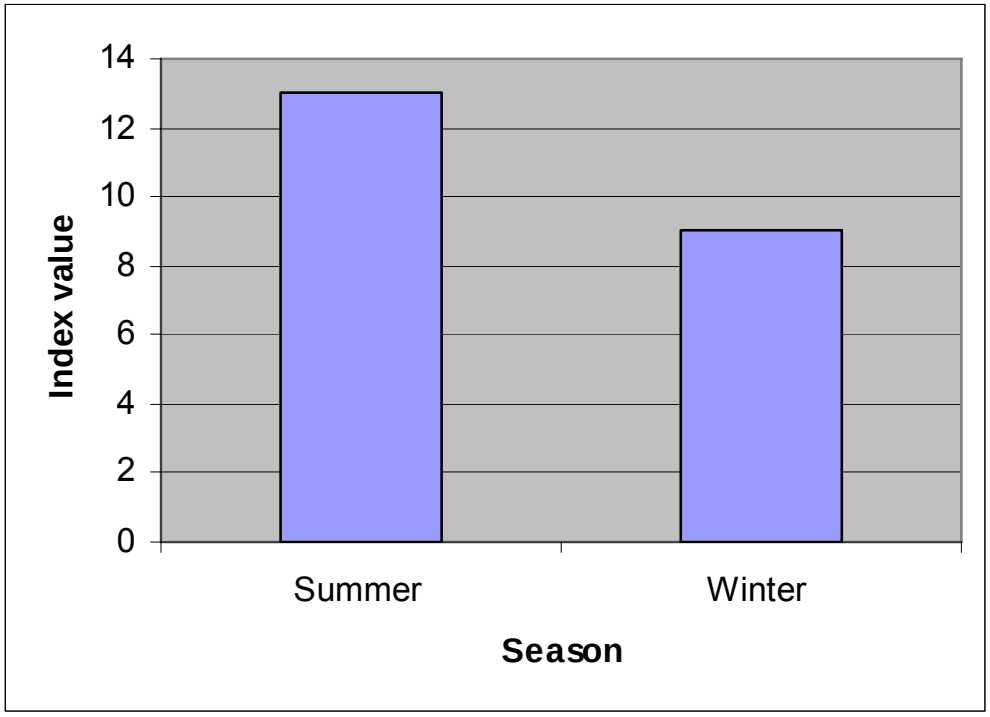


Figure 10 – Species evenness of reptile and amphibian recorded from Pai Forest over summer and winter

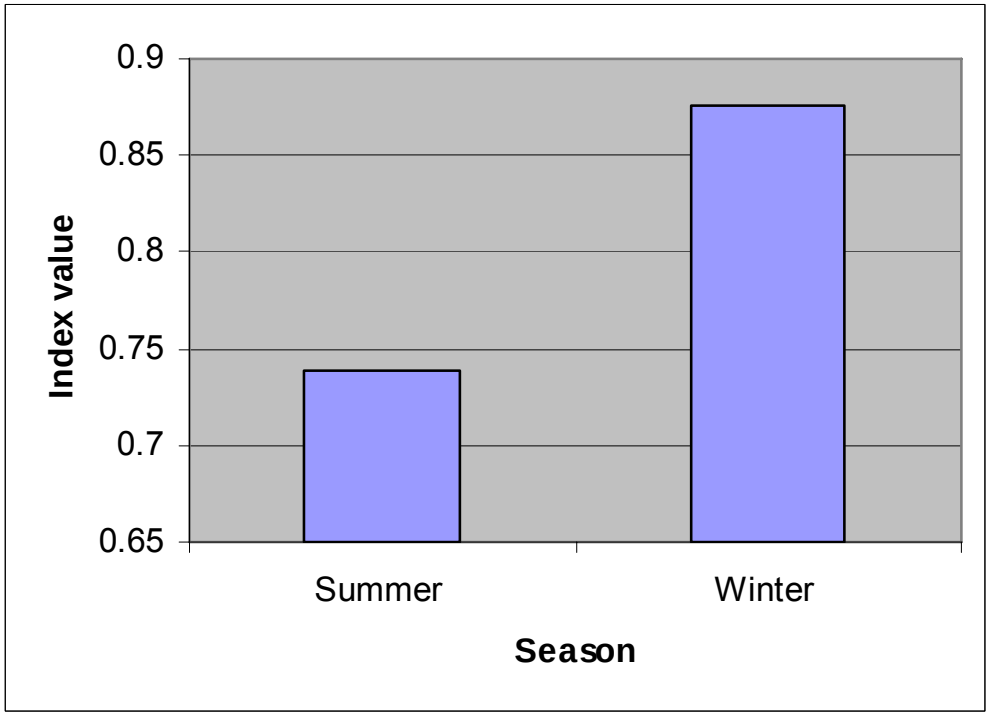
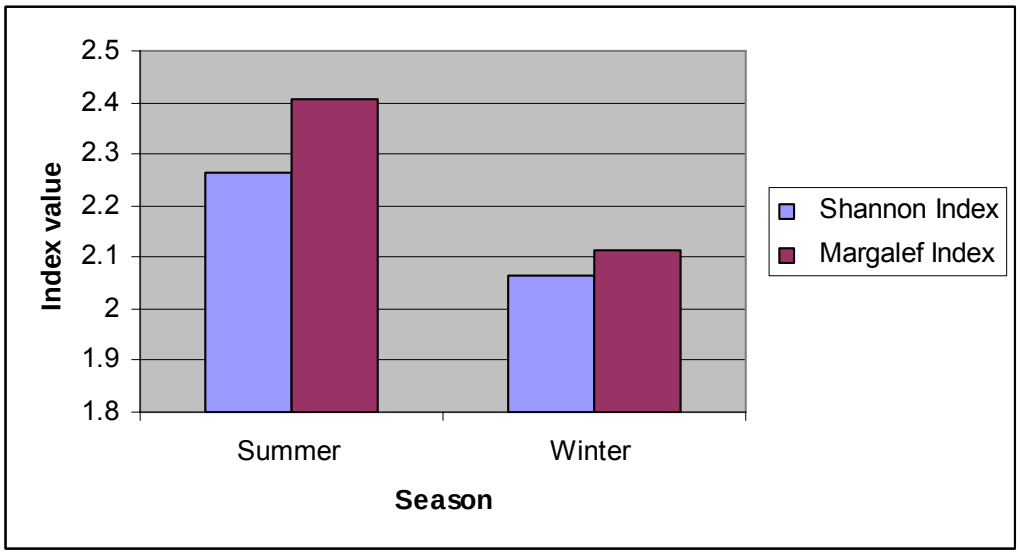


Figure 11 – Species diversity (Shannon and Margalef) for reptiles and amphibians recorded from Pai Forest over summer and winter



As can be seen from the results, Pai Forest supported more species in summer than winter. Given the hibernating nature of reptile and amphibians this is not an unusual phenomenon. Looking at the evenness, there is significance difference between the two seasons. Again, this is to be expected due to migration and hibernation of certain species.

Both species diversity indexes are uneven with higher diversity in summer than winter. Both Shannon and Margalef show a similar result over the seasons.

3.5.4 Threats and recommendations

3.5.4.1 Threats

- The forest is under extreme pressure of livestock grazing and woodcutting by the local communities thus destroying the habitat for the associated herpeto-fauna.

- The forest presents a gloomy picture and seems to be deprived of natural habitat structure for the amphibians and reptiles. The nearby agricultural lands and villages are one of the limiting factors for the survival and mobility of animals.

- The meager wildlife and forest department staff is technically not sound and poorly equipped.

- The locals are afraid of lizards and snakes and kill every individual that they encounter.

3.5.4.2 Recommendations

- The local communities and the wildlife staff should be educated about the importance of amphibian and reptilian fauna in the forest ecosystem through trainings, workshops, pamphlets and brochures;

- The water supply to the forest should be improved through more efficient practices;

- There is a need to carry out a year-long research study pertaining to the presence of Rock python in the forest;
- The cutting down of wood from the forest should be immediately prevented and the plantation of the actual non-invasive flora should be initiated;
- 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 of the forest, highlighting the nearby heavily populated amphibian or reptile species and the speed of vehicles must remain within limits accordingly.

3.6 Reptiles & Amphibians (Keti Shah)

3.6.1 Species account

Various localities in the forest were visited and both day and night surveys were conducted from 20 to 21 June 2007. Population of Brown River turtle *was* higher than any other turtle species. Bengal Monitor was one of the most frequently seen lizards in the forest. Similarly, Marbled toad population was the highest of all the amphibian species of the area. Checkered keel-back was the only snake observed during the summer studies. The studies conducted in the beginning of winter season resulted in finding several new species, previously not reported.

Image 13 - *Acacia nilotica* at Keti Shah

Image 14 – vegetation at Keti Shah

This forest is one of the low-lying Riverine forests dominated by *Acacia nilotica*. Other terrestrial vegetation includes *Tamarix dioica, T. aphylla, Prosopis juliflora, Alhaji maurorum* and *Populus euphratica*. Aquatic vegetation comprises of *Saccharum munja, S. bengalense, Typha angustata, T. latifolia, Phragmites karka* and *Persicaria orientalis*. The forest is divided in patches by main rivers, bye-rivers and several seasonal and permanent river channels/depressions and remains under water for 2-4 months. During flood season, wild animals migrate to high-lying areas of adjoining forests.

In the summer studies, out of 53 possibly occurring species of the area, 11 species of amphibians and reptiles were observed or collected and the remaining were identified through the local inhabitants after thorough discussions as well as by the earlier records in the literature. The studies were repeated in the beginning

of winter season and the author observed and collected 05 additional species of herpetiles including a single species of freshwater turtle *Kachuga tecta*, Gecko *Hemidactylus brookii*, colubrid snake *Ptyas mucosus* and two species of Elapids *Bungarus c caeruleus* and *Naja n. naja*. The table below provides the picture of current field studies conducted in different localities in and around the forest.

3.6.2 Species diversity

Table 23 highlights very high numbers in terms of richness, evenness, Shannon and Margalef indices of the observation and collection made during the summer survey.

Table 23 – Comparison of Amphibian and Reptilian diversity during summer and pre-winter studies at Keti Shah, District Sukkur

S. No	Species Name	Total	Summer	Winter
1	*Bufo stomaticus*	15	15	0
2	*Hoplobatrachus tigerinus*	04	04	0
3	*Aspideretes gangeticus*	05	03	02
4	*Kachuga tecta*	19	0	19
5	*Kachuga smithii*	62	28	34
6	*Hardella thurjii*	03	03	0
7	*Calotes v. versicolor*	05	05	0
8	*Hemidactylus brookii*	08	0	08
9	*Hemidactylus flaviviridis*	42	26	16
10	*Eutropis dissimilis*	06	06	0
11	*Varanus bengalensis*	13	13	0
12	*Eryx conicus*	03	03	0
13	*Ptyas m. mucosus*	03	0	03
14	*Xenochrophis p. piscator*	04	04	0
15	*Bungarus c. caeruleus*	02	0	02
16	*Naja n. naja*	01	0	01
	Total (number of individuals collected)	195	110	85

Table 24 – Results of different indexes

S.no	Index type	Summer	Winter
1	**Richness (number of species)**	11	08
2	**Evenness**	0.7049	0.6099
3	**Shannon Index**	2.048	1.585
4	**Margalef Index**	2.127	1.576

Figure 12 – Species diversity of reptiles and amphibians at Keti Shah over summer and winter

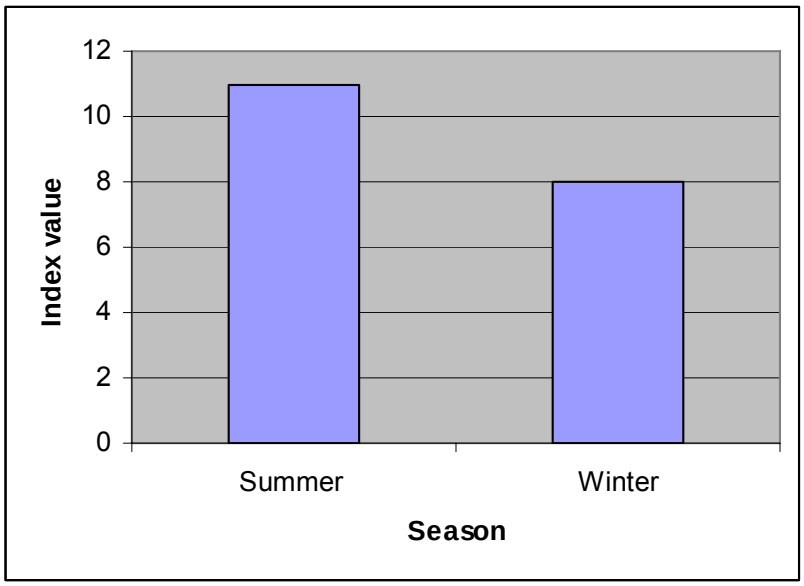


Figure 13 – Species evenness of reptile and amphibian recorded from Keti Shah over summer and winter

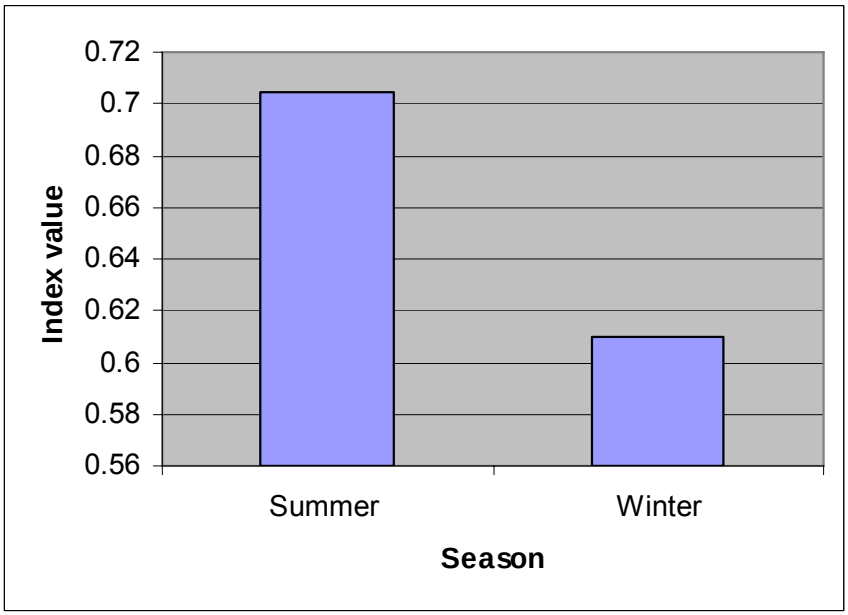
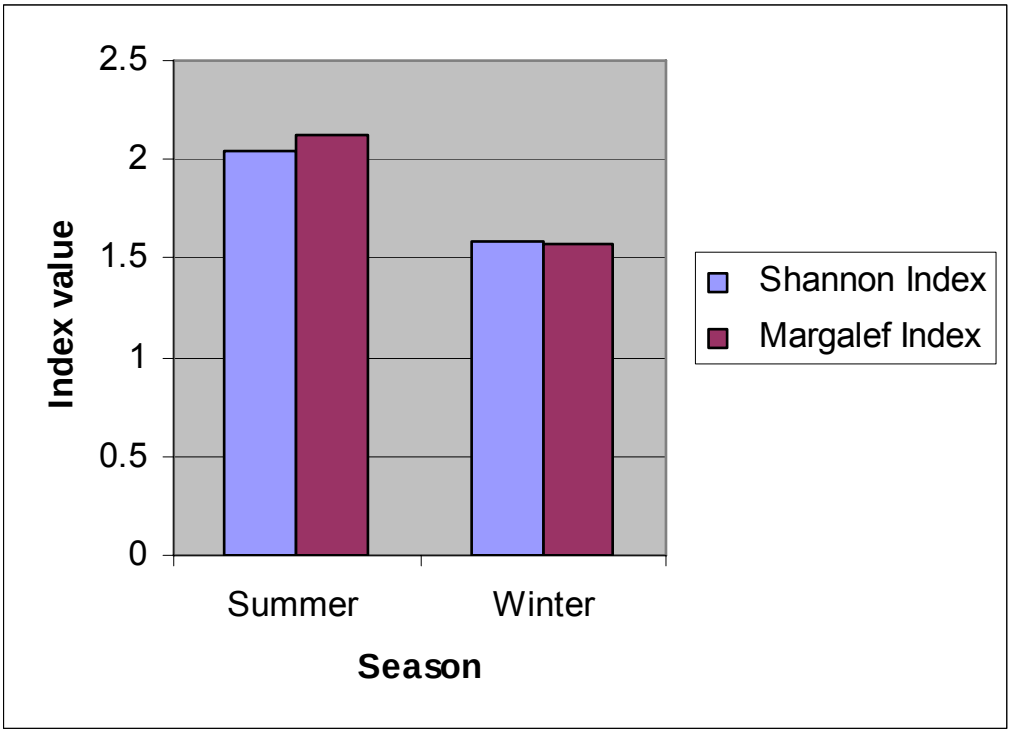


Figure 14 – species diversity (Shannon and Margalef) for reptiles and amphibians recorded from Keti Shah over summer and winter



As with most sites, the evenness of reptile and amphibians is variable over seasons. Surprisingly the Shannon and Margalef are similar in results. Like most sites, there were more species in summer than winter. There was more evenness in summer than winter.

3.6.3 Threats and recommendations

3.6.3.1 Threats

- Annual floods characterize this Riverine forest, a phenomenon that is threatening the existence of reptile species and their distributional pattern;
- The physical features of the area keep changing due to the flow of Indus River, thus, limiting the herpetile mobility and survival;
- Accessibility to the area is very difficult; hence proper observation and monitoring of amphibians and reptiles is a cumbersome and time-consuming task;
- This forest is also one of the fragile habitats of all the programme sites due to the uneven physical features caused by annual floods;
- There is an un-checked and un-controlled cutting of trees by local communities for fuel wood and other purposes. This deprives the reptiles of their already decreasing habitat;
- The locals are afraid of lizards and snakes and kill every individual that they encounter, leading to the depletion of these animals.

3.6.3.2 Recommendations

- The local communities and the wildlife staff should be educated about the importance of amphibian and reptilian fauna in the forest ecosystem through trainings, workshops, pamphlets and brochures;

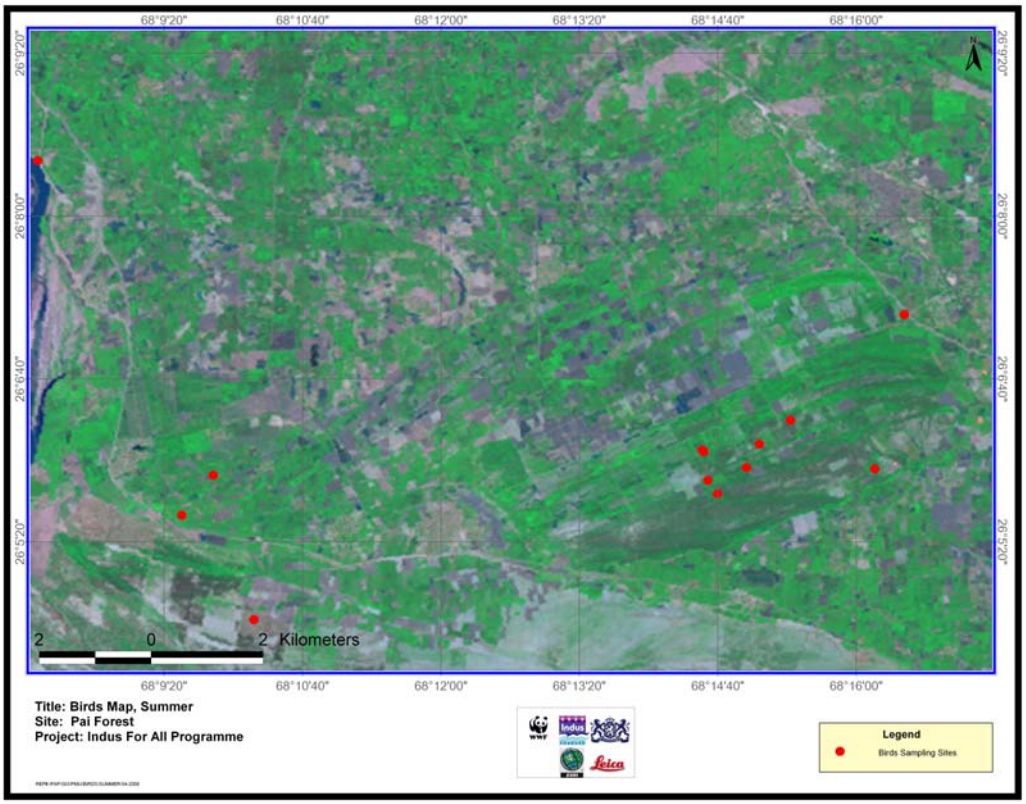
- The staff of wildlife and forest department should be provided with environment-friendly equipment including the latest boats for monitoring of animals in different areas of the forest;
- The cutting down of wood from the forest should be immediately prevented through enforcing the legislations
- The local communities should be provided with alternate means for their livelihoods including micro-financing;

3.7 Birds (Pai Forest)

3.7.1 Sample location

Map 9 and **10** show the observation locations for bird surveys at Pai Forest over summer and winter. Full details of the observation points and birds recorded are available in the annexure document.

Map 9 – bird observation points at Pai Forest during summer



Map 10 – bird observation points at Pai Forest during winter

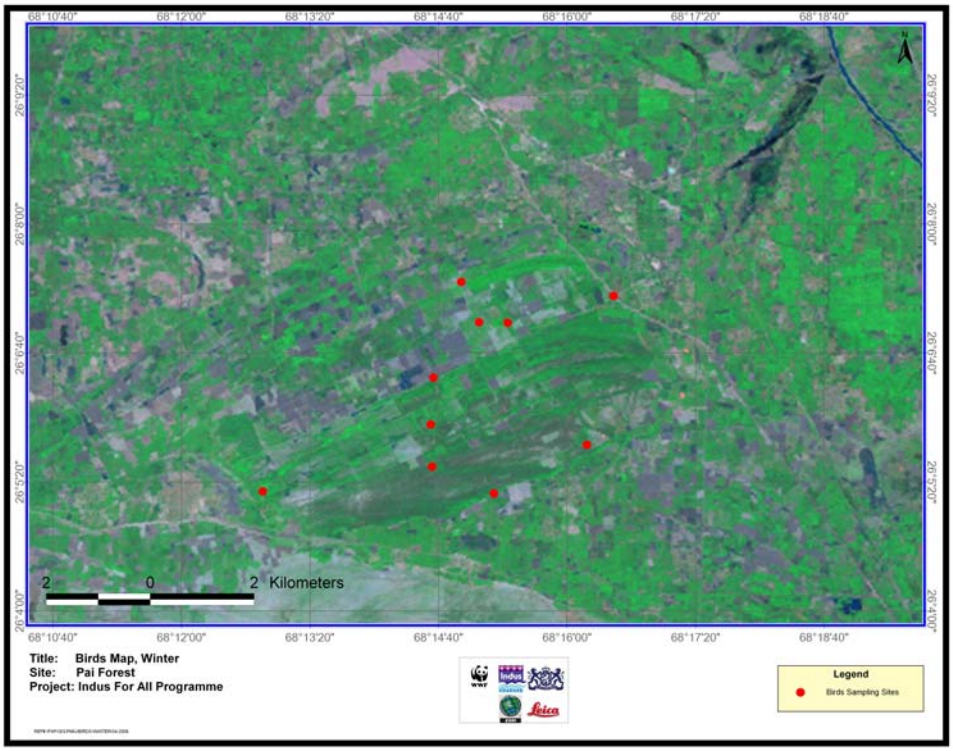


Image 15 – Blue throat at Pai Forest

Image 16 – Cattle Egret at Keti Shah

3.7.2 Species account

3.7.2.1 Summer

Table 25 gives the list of bird species observed from Pai Forest during summer. A total of 54 species were observed in and around the forest.

Table 25 – List of bird species recorded from Pai Forest during summer

No	Common Name	Scientific Name	Status	Occurrence	Observed Number
1	Indian Pond Heron	*Ardeola grayii*	Common	Resident	14
2	Cattle Egret	*Bubulus ibis*	Common	Resident	55
3	Crested Honey Buzzard	*Pernis ptilorhynchus*	Scarce	Resident	03
4	Brahminy Kite	*Haliastur Indus*	Rare	Resident	01
5	Indian Grey Partridge	*Francolinus pondicerianus*	Scarce	Resident	02

6	Baillon's Crake	*Porzana pusilla*	Scarce	Winter visitor	02
7	White breasted Water Hen	*Amanrormis phoenicurus*	Scarce	Resident	02
8	Red wattled Lapwing	*Hoplopterus Indus*	Common	Resident	61
9	Green Sandpiper	*Tringa ochropus*	Scarce	Winter visitor	04
10	Blue Rock Pigeon	*Columba livia*	Common	Resident	37
11	Collared Dove	*Streptopelia decaoto*	Common	Resident	91
12	Red Turtle Dove	*Streptopelia tranquebarica*	Scarce	Resident	16
13	Little Brown Dove	*Streptopelia seneghalensis*	Common	Resident	102
14	Common Green Pigeon	*Treron phoenocoptera*	Rare	Irr-year round visitor	10
15	Rose-ringed Parakeet	*Psittacula krameri*	Common	Resident	37
16	Pied Crested Cuckoo	*Clamator jacobinus*	Scarce	Resident	01
17	Common Koel	*Eudynamys scolopacea*	Scarce	Resident	02
18	Common Crow Pheasant	*Centropus sinensis*	Common	Resident	11
19	Spotted Owlet	*Athene brama*	Common	Resident	02
20	Sykes's/Sind Night Jar	*Caprimulgus mahrattensis*	Scarce	Resident	02
21	White breasted King Fisher	*Halcyon smyrnensis*	Scarce	Resident	05
22	Little Green Bee eater	*Merops orientalis*	Common	Resident	131
23	Indian roller	*Coracias benghalensis*	Common	Resident	91
24	Lesser Golden-backed Wood pecker	*Dinopium benghalensis*	Common	Resident	04
25	Yellow-fronted Wood pecker	*Dendrocopos mahrattensis*	Rare	Resident	01
26	Small Minivet	*Pericrocotus cinnamomeus*	Scarce	Resident	06
27	White Cheeked Bulbul	*Pycnonotus leucogenys*	Common	Resident	56
28	Red-vented Bulbul	*Pycnonotus cafer*	Common	Resident	09
29	Pied Bush Chat	*Saxicola caprata*	Common	Resident	17
30	Indian Robin	*Saxicoloides fulicata*	Common	Resident	11
31	Plain Coloured Prinia	*Prinia inornata*	Common	Resident	05
32	White-browed Fan tail Fly catcher	*Phipidurata aureola*	Scarce	Resident	02
33	Common Babbler	*Turdoides caudatus*	Common	Resident	07
34	Striated Babbler	*Turdoides earlei*	Common	Resident	17
35	Jungle Babbler	*Turdoides striatus*	Common	Resident	53
36	Purple Sun Bird	*Nectarinia asiatica*	Common	Resident	38
37	Long-tailed Shrike	*Lanius schach*	Scarce	Resident	02
38	Black Drongo	*Dicrurus macrocercus*	Common	Resident	34
39	Indian Tree-Pie	*Dendrocitta vagabunda*	Common	Resident	20

40	Indian House Crow	*Corvus splendens*	Common	Resident	119
41	Common Starling	*Sturnus vulgaris*	Scarce	Winter visitor	03
42	Common Myna	*Acridotheres tristis*	Common	Resident	83
43	Bank Myna	*Acridotheres ginginianus*	Common	Resident	130
44	Indian House Sparrow	*Passer domesticus*	Common	Resident	51
45	Yellow throated Sparrow	*Petronia xanthocollis*	Common	Resident	85
46	White throated Munia	*Eodice malabarica*	Common	Resident	12
47	Bay-backed Shrike	*Lanius vittatus*	Scarce	Resident	02
48	Streaked/Graceful Prinia	*Prinia gracilis*	Common	Resident	09
49	Ashy-crowned Finch Lark	*Eremopterix grisea*	Common	Resident	14
50	Indian Sky Lark	*Alauda gulgula*	Common	Resident	08
51	Sind Pied Wood pecker	*Dendrocopos assimilis*	Scarce	Resident	01
52	Tailor Bird	*Orthotomus sutorius*	Common	Resident	05
53	Paddy-field Pipit	*Anthus rufulus*	Scarce	Summer breeder	03
54	Crested Lark	*Galerida cristata*	Common	Resident	05
55	Shikra	*Accipiter badius*	Scarce	Resident	02
56	Rufous fronted Prinia	*Prinia buchanani*	Scarce	Resident	04

3.7.2.2 Winter

Table 26 shows the list of bird species recorded from Pai Forest during winter. A total of 61 species were recorded.

Table 26 – List of species recorded from Pai Forest during winter

S. No.	Common Name	Scientific Name	Status	Occurrence	Obser No.
1	Indian Pond Heron	*Ardeola grayii*	Less common	Resident	04
2	Cattle Egret	*Bubulcus ibis*	Common	Resident	195
3	Little Egret	*Egretta garzetta*	Less common	Resident	02
4	Crested Honey Buzzard	*Pernis ptilorhynchus*	Less common	Irregular year round visitor	03
5	Black Shouldered Kite	*Elanus caeruleus*	Less common	Resident	02
6	Black Kite	*Milvus migrans*	Abundant	Resident	13
7	Brahminy Kite	*Haliastur indus*	Rare	Resident	02
8	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Scarce	Resident	02
9	Eurasian Sparrow Hawk	*Accipiter nisus*	Frequent	Winter visitor	01
10	Indian Sparrow Hank	*Accipiter badius*	Common	Winter	01

				visitor	
11	Indian Grey Partridge	*Francolinus pondicerianus*	Less common	Winter visitor	20
12	Black-winged Stilt	*Hemantopus himantopus*	Common	Winter visitor	13
13	Red Wattled Lapwing	*Hoploterus indicus*	Common	Winter visitor	79
14	Little Stint	*Calidris minuta*	Common	Winter visitor	31
15	Red Shank	*Tringa totanus*	Less common	Winter visitor	04
16	Green Shank	*Tringa nebularia*	Less common	Winter visitor	05
17	Common Sandpiper	*Actitis hypoluneos*	Less common	Winter visitor	05
18	Indian River Tern	*Sterna aurantia*	Less common	Winter visitor	11
19	Blue Rock Pigeon	*Columbar livia*	Common	Resident	54
20	Indian Collared Dove	*Streptopelia decaocto*	Common	Resident	26
21	Little Brown Dove	*Streptopelia senegalensis*	Common	Resident	101
22	Rose Ringed Parakeet	*Psittacula krameri*	Less common	Resident	07
23	Common Crow Pheasant	*Centropus sinensis*	Less common	Resident	02
24	Indian Great Horned Owl	*Bubo bubo*	Rare	Resident	01
25	Spotted Owlet	*Athene brama*	Less common	Resident	04
26	Lesser Pied Kingfisher	*Ceryle rudis*	Less common	Resident	03
27	Little Green Bee-eater	*Merops orientalis*	Less common	Resident	33
28	Indian Roller	*Coracias benghalensis*	Less common	Resident	06
29	Lesser Golden Backed Woodpecker	*Dinopiium benghalense*	Less common	Resident	04
30	Sindh pied woodpecker	*Dendrocopos assimilis*	Less common	Resident	03
31	Indus Sand Lark	*Calandrella raytal*	Less common	Resident	04
32	Crested Lark	*Galerida cristata*	Less common	Resident	06
33	Plain Sand Martin	*Riparia paludicoda*	Common	Resident	66
34	Common Swallow	*Hirumdo rustica*	Common	Winter visitor	45
35	Paddy Field Pipit	*Anthus rufulus*	Less	Resident	07

			common		
36	White Wagtail	*Motacilla alba*	Less common	Winter visitor	25
37	Common Wood Shrike	*Tephrodornis pondicercanus*	Less common	Resident	02
38	White Cheeked Bulbul	*Pycnonotus leucogenys*	Common	Resident	31
39	Red Vented Bulbul	*Pyicnonotus cafer*	Less common	Resident	06
40	Blue Throat	*Luscinia svecica*	Rare	Winter visitor	01
41	Black Redstart	*Phoenicurus ochruros*	Common	Winter visitor	16
42	Pied Bush Chat	*Saxicola caprata*	Less common	Resident	07
43	Eastern Pied Wheatear	*Oenanthe picata*	Less common	Winter visitor	03
44	Indian Robin	*Saxicoloides fulicata*	Common	Resident	25
45	Plain Coloured Prinia	*Prinia inornata*	Less common	Resident	04
46	Yellow bellied Prinia	*Prinia flavoventris*	Less common	Resident	02
47	Tailor Bird	*Orthotomus sutorius*	Less common	Resident	04
48	Lesser Whitethroat	*Sylvia curruca*	Common	Winter visitor	21
49	Common Babbler	*Turdoidus caudatus*	Common	Resident	86
50	Striated Babbler	*Turdoidus carlei*	Less common	Resident	07
51	Jungle Babbler	*Turdoidus striata*	Common	Resident	70
52	Purple Sunbird	*Nectarinia asiatica*	Common	Resident	12
53	Isabelline Shrike	*Lanius isabellinus*	Less common	Winter visitor	05
54	Long-tailed Shrike	*Lanius schach*	Less common	Resident	02
55	Black Drongo	*Dicrurus macrocercus*	Common	Resident	15
56	Indian Tree-pie	*Dendrocitta vagabunda*	Common	Resident	13
57	Indian House Crow	*Corvus splendens*	Common	Resident	110

58	Common Myna	*Acridotheres tristis*	Common	Resident	30
59	Bank Myna	*Acridotherus ginginianus*	Less common	Resident	09
60	Indian Horse Sparrow	*Passer domesticus*	Abundant	Resident	325
61	Yellow Throated Sparrow	*Petronia xanthocollis*	Common	Resident	13
				TOTAL	1499

3.7.3 Summer and winter comparison

Figure **15** to **17** shows the results of the summer and winter surveys. More species were observed in summer, though by only a margin (5 species).

Figure 15 – Number of species, families and order recorded in the summer and winter season.

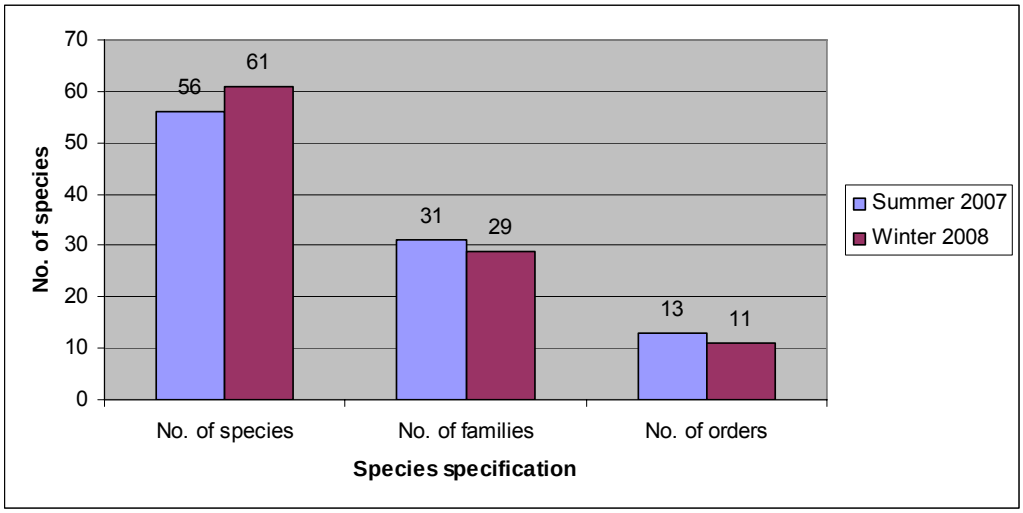
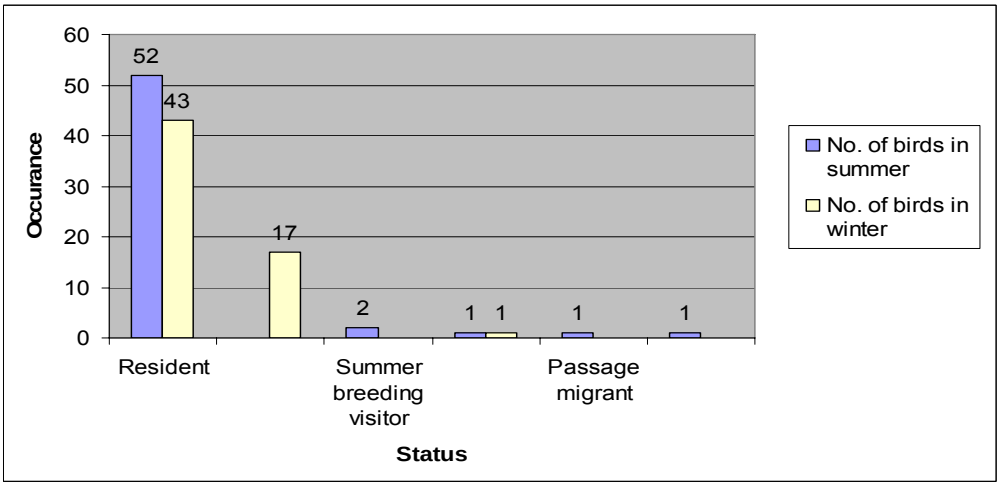


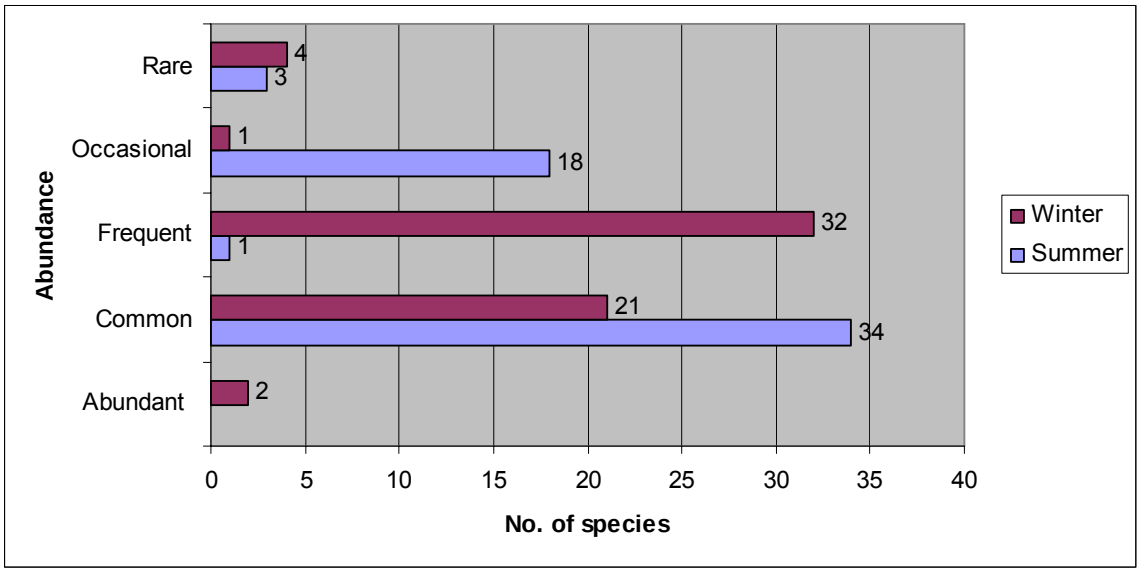
Figure 16 – Species occurrence in the study area showing the seasonal status.



3.7.4 Occurrence and abundance

Figures 16 and **17** show the occurrence and abundance of bird species at Pai Forest over summer and winter. Most of the birds recorded in summer and winter were resident. This reflects the importance of such habitats and though often importance is given to wetland habitat, it is easy to forget the other habitats that are important to resident species. Most of the birds recorded at Pai Forest were frequent or common though there were quite a few occasional species in summer. Rare and abundant species not commonly registered during the surveys.

Figure 17 – Species Abundance during summer and winter season.



3.7.5 Threats and recommendations

3.7.5.1 Threats

- Hunting and poaching is the main threat to the birds and human disturbance in general is also a problem. Hunting of partridges out of season e.g. in the breeding season is extremely detrimental to the local population;

- Removal of habitat, especially undergrowth in and around Pai Forest is resulting in poor reproductive success. The problem is also exuberated by lack of water and the subsequent drought situation that it creates. This affects the habitat, especially the variety of grasses and herbaceous plants that are important for terrestrial birds;

- Though there is no direct evidence, the relatively intensive agriculture and use of agro-chemicals may be affecting the ability of bird species to survive in the area;

- Cutting of mature trees is especially harmful to certain species of birds that rely on these for feeding and breeding.

3.7.5.2 Recommendations

- Efforts should be made to manage and control the hunting and poaching. Demonstration in other parts of the country have shown that community managed game reserves are instrumental in managing wildlife

populations. Such a model could be experimented on the peripheries of the forested area;

- There is also a need to develop a conservation plan that will encompass interventions for the bird species found in and around Pai Forest. This should include zoning of the forest so that disturbance is reduced to a minimum;

- An environmental awareness outreach programme needs to be initiated, targeting local community at various levels. This outreach programme should include topics such as the importance of birds as pest controllers and seed dispersers.

- Some initiative should be taken to reduce the dependency of local community on the forest, especially in terms of fuel-wood and fodder which, through collection causes disturbance to birds and removes habitat. Alternatives to fuel-wood and fodder should be provided to the local inhabitants.

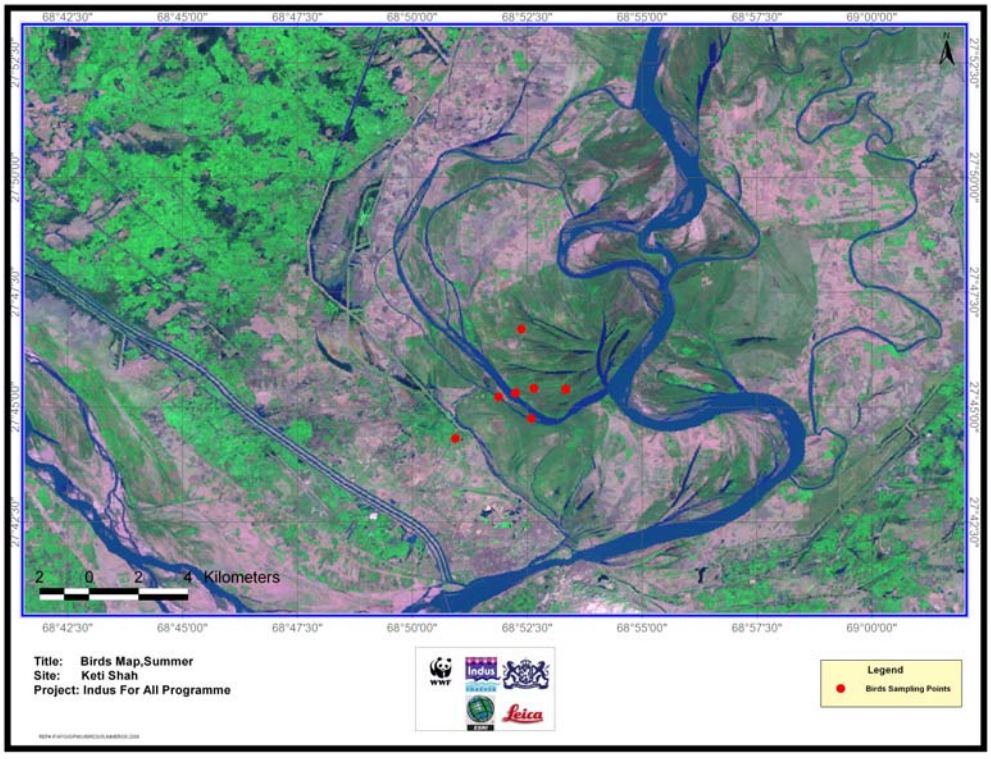
- Efforts should be made to ensure sufficient water supply to the area so that vegetative growth can be supported throughout the seasons.

3.8 Birds (Keti Shah)

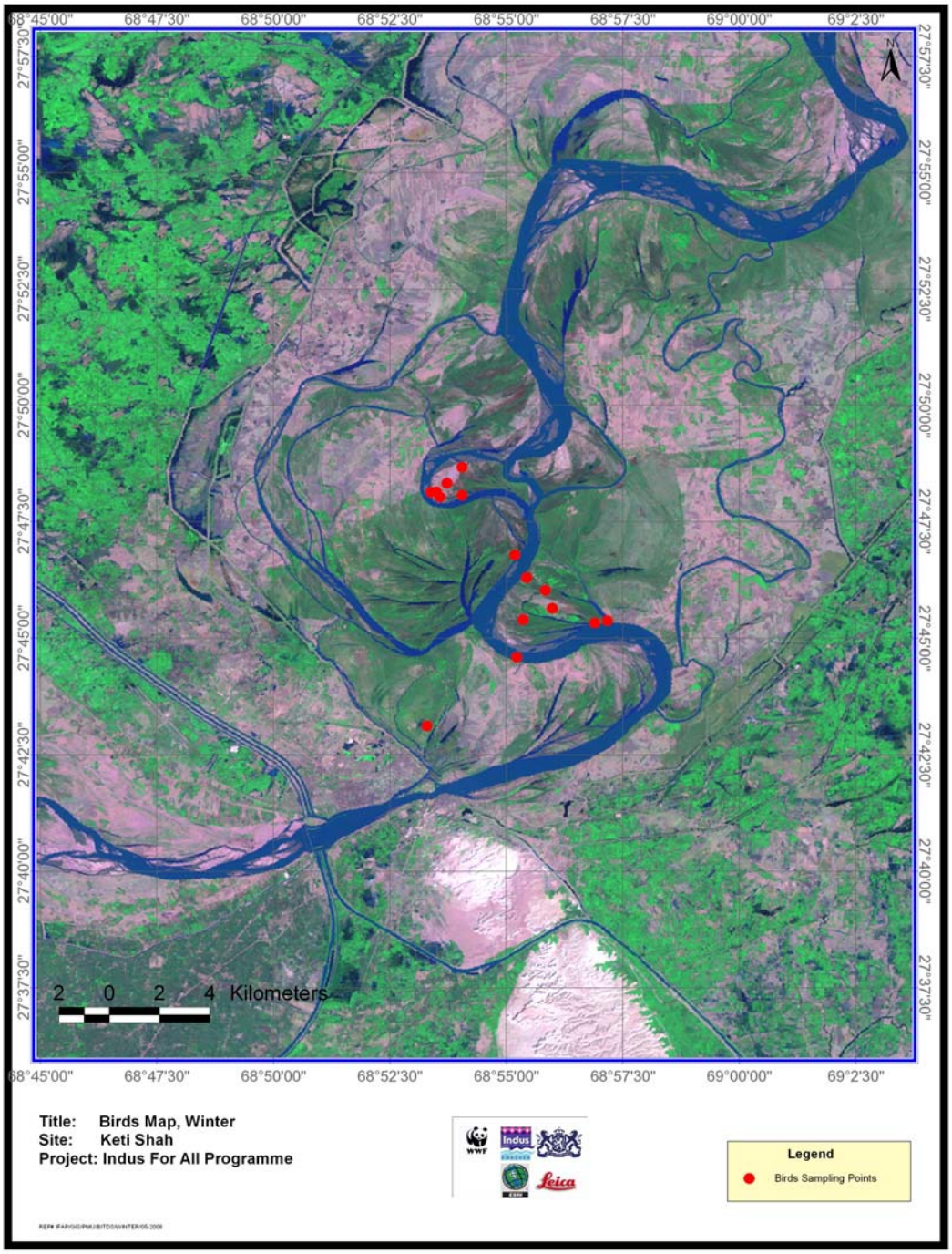
3.8.1 Sampling locations

Map 11 and **12** shows the observation points for birds at Keti Shah during summer. Details of each sampling point can be found in the annexure document.

Map 11 – Showing observation points of bird surveys in Keti Shah during summer



Map 12 – Showing observation points of bird surveys in Keti Shah during winter



3.8.2 Species account

The summer surveys of birds were undertaken during June 2007 and January 2008. A total of 54 species of birds were recorded in the summer surveys while 47 species were recorded in the winter surveys.

3.8.2.1Summer

Table 27 gives the list of bird species recorded at Keti Shah during summer, along with the status, occurrence and number of individuals observed.

Table 27 – List of bird species recorded from Keti Shah during summer

S.no	Common Name	Scientific Name	Status	Occurrence	Observed Number
1	Little Cormorant	*Phalacrocorax niger*	Common	Resident	12
2	Black Bittern	*Ixobrychus flavicollis*	Scarce	Resident	04
3	Indian Pond Heron	*Ardeola grayii*	Common	Resident	92
4	Cattle Egret	*Bubulcus ibis*	Common	Resident	17
5	Little Egret	*Egretta garzetta*	Common	Resident	33
6	Grey Heron	*Ardea cinerea*	Scarce	Winter visitor	03
7	Crested Honey Buzzard	*Prenis ptilorhynchus*	Scarce	Irr-year round visitor	04
8	Black Kite	*Milvus migrans*	Common	Resident	77
9	Brahminy Kite	*Haliastur Indus*	Rare	Resident	04
10	Black Partridge	*Francolinus francolinus*	Scarce	Resident	02
11	Indian Grey Partridge	*Francolinus pondicerianus*	Scarce	Resident	02
12	Black winged Stilt	*Himantopus himantopus*	Common	Resident	08
13	White tailed Lapwing	*Chettusia leucura*	Common	Winter visitor	08
14	Red-wattled Lapwing	*Hoplopterus indicus*	Common	Resident	154
15	Small Indian Pratincole	*Glareola lactea*	Common	Summer breeder	08
16	Indian River Tern	*Sterna aurantia*	Common	Resident	48
17	Black-bellied Tern	*Strena acuticauda*	Rare	Rare	02
18	Blue Rock Pigeon	*Columba livia*	Common	Resident	124
19	Collared Dove	*Streptopelia decaocto*	Common	Resident	42
20	Little Brown Dove	*Streptopelia senegalensis*	Common	Resident	64
21	Rose-ringed Parakeet	*Psittacula krameri*	Common	Resident	06
22	Pied crested cuckoo	*Clamator jacobinus*	Scarce	Summer breeder	01
23	Common Crow Pheasant	*Centropus sinensis*	Common	Resident	06
24	Little/House Swift	*Apus affinis*	Common	Resident	134
25	White breasted Kingfisher	*Halcyon smyrnensis*	Common	Resident	10
26	Pied King Fisher	*Ceryl rudis*	Common	Resident	30
27	Little Green Bee-eater	*Merops orientalis*	Common	Resident	182

28	Indian Roller	*Coracias benghalensis*	Common	Resident	04
29	Crested Lark	*Galerida cristata*	Common	Resident	16
30	Plain Sand Martin	*Riparia paludicola*	Common	Resident	656
31	Common/Barn Swallow	*Hirundu rustica*	Common	Winter visitor	04
32	White browed Wagtail	*Motacilla maderaspatensis*	Scarce	Resident	02
33	White-cheeked Bulbul	*Pycnonotus leucogenys*	Common	Resident	46
34	Red-vented Bulbul	*Pycnonotus cafer*	Common	Resident	12
35	Pied Bush Chat	*Saxicola caprata*	Common	Resident	14
36	Indian Robin	*Saxicoloides fulicata*	Scarce	Resident	02
37	Rufous-fronted Prinia	*Prinia buchanani*	Common	Resident	08
38	Plain coloured Prinia	*Prinia inornata*	Common	Resident	08
39	Common Babbler	*Turdoides caudatus*	Common	Resident	18
40	Striated Babbler	*Turdoides earlei*	Common	Resident	28
41	Jungle Babbler	*Turdoides striatus*	Common	Resident	36
42	Purple Sun Bird	*Nectarinia asiatica*	Common	Resident	17
43	Bay-Backed Shrike	*Lanius vittatus*	Scarce	Resident	02
44	Black Drongo	*Dicrurus macrocercus*	Common	Resident	20
45	Indian Tree-Pie	*Demdrocitta vagabunda*	Scarce	Resident	02
46	Indian House Crow	*Corvus splendens*	Common	Resident	229
47	Common Myna	*Acridotheres tristis*	Common	Resident	81
48	Bank Myna	*Acridotheres ginginiamus*	Common	Resident	115
49	Indian House Sparrow	*Passer domesticus*	Common	Resident	278
50	Sindh Jungle Sparrow	*Passer pyrrhonotus*	Scarce	Resident	03
51	Streaked Weaver	*Ploceus manyar*	Common	Resident	73
52	Baya Weaver	*Ploceus philippinus*	Scarce	Resident	43
53	Rose-coloured Starling	*Sturnus roseus*	Scarce	Resident	29
54	Common Koel	*Eudynamus scolopacea*	Scarce	Resident	02
				TOTAL	3825

3.8.2.2 Winter

Table 28 gives the list of bird species recorded at Keti Shah during winter, along with the status, occurrence and number of individuals observed. A total of 47 species were observed during the winter survey at Keti Shah.

Table 28 – List of bird species recorded from Keti Shah during winter

S. No.	Common Name	Scientific Name	Status	Occurrence	Obser No.
1	Black Crowned Night Heron	*Nycticorax nyticorax*	Less Common	Resident	08
2	Indian Pond Heron	*Ardeola grayii*	Less	Resident	09

			Common		
3	Cattle Egret	*Bubulcus ibis*	Less Common	Resident	49
4	Little Egret	*Egretta garzetta*	Less Common	Resident	22
5	Great White Egret	*Casmerodius alba*	Less Common	Resident	44
6	Grey Heron	*Ardea cinerea*	Less Common	Resident	142
7	Purple Heron	*Ardea purpurea*	Scarce	Resident	01
8	White Spoonbill	*Platalea leucorodia*	Less Common	Winter Visitor	07
9	Eurasian Widgeon	*Anas penepole*	Common	Winter Visitor	59
10	Gadwall	*Anas strepera*	Common	Winter Visitor	149
11	Common Teal	*Anas crecca*	Common	Winter Visitor	387
12	Mallard	*Anas platyrhynchos*	Common	Winter Visitor	87
13	Northern Shoveller	*Anas clypeata*	Common	Winter Visitor	38
14	Tufted Duck	*Aythyya fuligula*	Common	Winter Visitor	109
15	Crested Honey Buzzard	*Pernis ptilorhynchus*	Less Common	Year Round Visitor	04
16	Black Kite	*Milvus migrans*	Common	Resident	301
17	Pallas's Fish Eagle	*Haliaeetus leucoryphus*	Scarce	Resident	02
18	Egyptian Vulture	*Neophron percnopterus*	Scarce	Resident	02
19	Marsh Harrier	*Circus aeruginosus*	Less Common	Winter Visitor	06
20	Shikra	*Accipiter badius*	Scarce	Resident	02
21	White-eyed Buzzard	*Butastur teesa*	Scarce	Resident	01
22	Common Buzzard	*Buteo buteo*	Scarce	Winter Visitor	01
23	Greater Spotted Eagle	*Aquila clanga*	Scarce	Winter Visitor	02
24	Osprey	*Pandion haliaetus*	Scarce	Winter Visitor	02
25	Black partridge	*Francolinus francolinus*	Less Common	Resident	07
26	Indian Grey Partridge	*Francolinus pondicerianus*	Common	Resident	10

27	Black-winged Stilt	*Himantopus himantopus*	Common	Resident	15
28	Small Indian Pratincole	*Glareola lactea*	Less Common	Summer Visitor	04
29	Red-wattled Lapwing	*Hoplopterus indicus*	Common	Resident	15
30	White-tailed Lapwing	*Chettusia leucura*	Common	Winter Visitor	14
31	Spotted/Dusky Red Shank	*Tringa erythropus*	Less Common	Winter Visitor	05
32	Common Red Shank	*Tringa totanus*	Common	Winter Visitor	21
33	Green Shank	*Tringa nebularia*	Common	Winter Visitor	34
34	Green Sandpiper	*Tringa ochropus*	Less Common	Winter Visitor	06
35	Common Sandpiper	*Actitis hypoleucos*	Less Common	Winter Visitor	04
36	Caspian Tern	*Sterna caspia*	Scarce	Winter Visitor	02
37	Indian River Tern	*Sterna aurantia*	Common	Resident	51
38	Black-bellied Tern	*Sterna acuticunda*	Less Common	Resident	12
39	Indian Collared Dove	*Streptopelia decaoto*	Common	Resident	120
40	Red-turtle Dove	*Streptopelia tranquebarica*	Less Common	Summer Visitor	05
41	Little Brown Dove	*Streptopelia senegalensis*	Common	Resident	206
42	Common Crow Pheasant	*Centropus sinensis*	Less Common	Resident	04
43	Spotted Owlet	*Athene brama*	Scarce	Resident	02
44	Little House Swift	*Apus affinis*	Scarce	Resident	04
45	White-throated Kingfisher	*Halcyon symrnesis*	Less Common	Resident	05
46	Common Kingfisher	*Alcedo atthis*	Less Common	Resident	08
47	Lesser Pied Kingfisher	*Ceryle rudis*	Common	Resident	20

3.8.3 Summer and winter comparison

Figure 18 to **20** show the results of the bird's surveys over summer and winter. More bird species were observed during summer than winter. Most of the species recorded in summer were summer residents with only a handful of breeding visitors. In winter twenty-six species were resident whereas the remaining were winter migrants.

Figure 18 – Number of species, families and orders recorded during summers and winter seasons

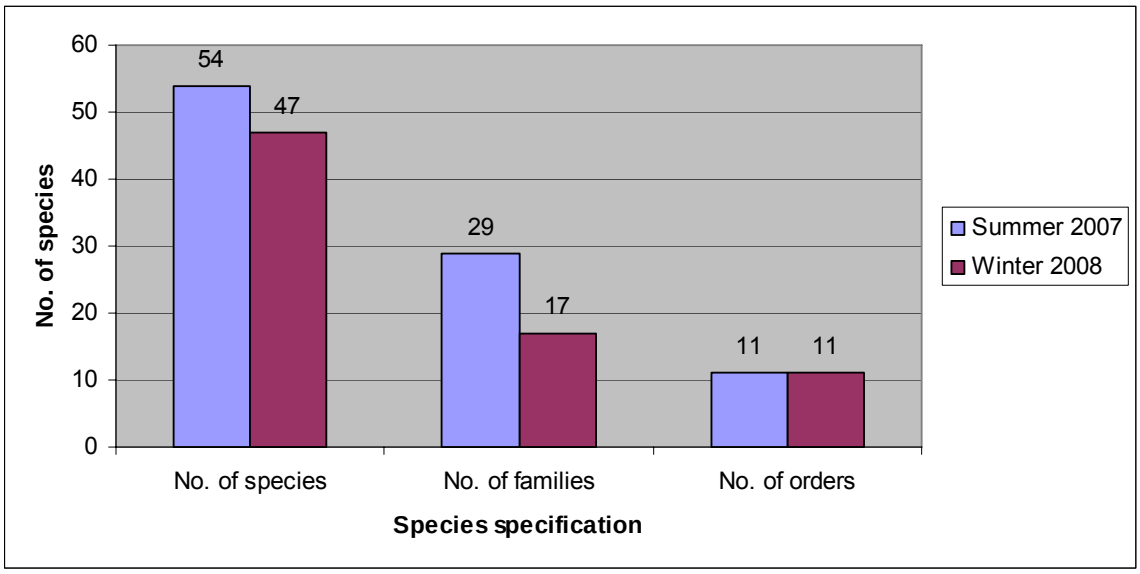
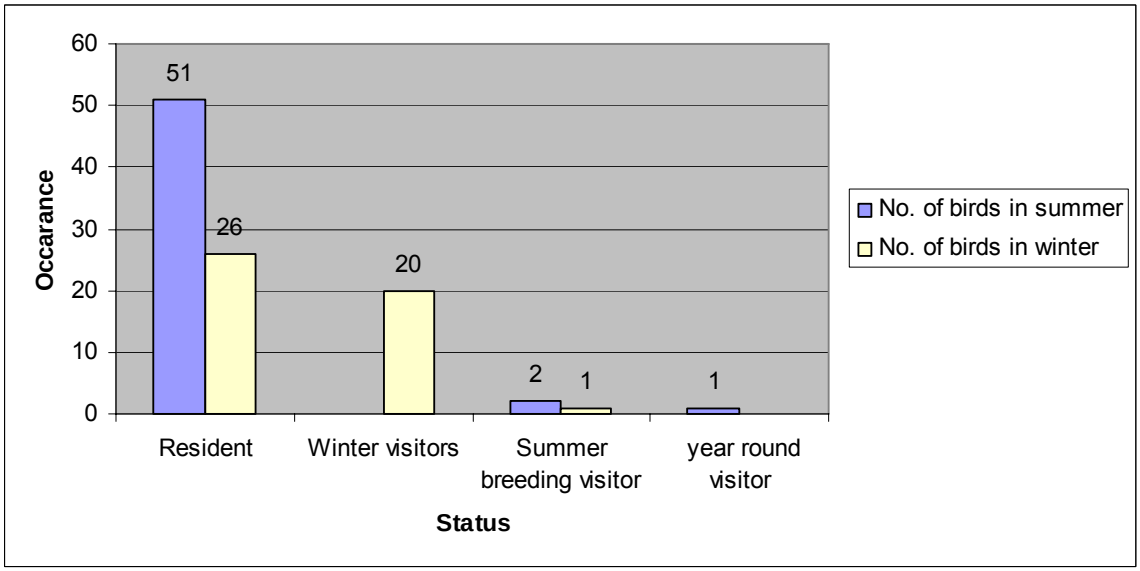
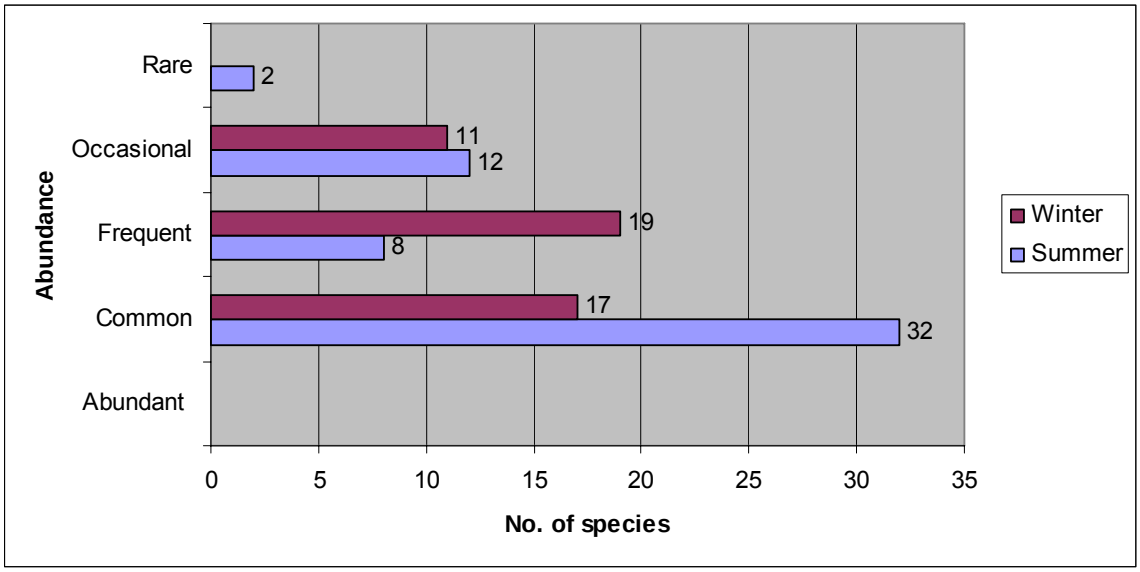


Figure 19 – Species occurrence in the study area showing the seasonal status



Most of the birds recorded in summer were common (32 species), followed by occasional, frequent and rare (only two were recorded from the latter category. During winter the birds were divided between resident and winter visitors.

Figure 20 – Bird species abundance during summer and winter season



3.8.4 Threats and recommendations

3.8.4.1 Threats

- Hunting and poaching of game birds is a major threat of the area. The law and order situation around the area does not permit patrolling by the Sindh Wildlife Department;

- Habitat removal especially that of riverine forest is reducing the ability of bird species to feed and breed in the area. Cutting of mature trees is especially harmful to certain species of birds that rely on these for feeding and breeding;

- Though there is no direct evidence, the relatively intensive agriculture and use of agro-chemicals may be affecting the ability of bird species to survive in the area.

3.8.4.2 Recommendations:

- The area needs to be developed as a protected area on account of its importance as a remnant example of riverine forest in Sindh. However, to accomplish this the law and situation needs to be improved to ensure the safety of visitors;

- There is also a need to develop a conservation plan that will encompass interventions for the bird species found in and around Keti Shah. This should include zoning of the forest so that disturbance is reduced to a minimum;

- An environmental awareness outreach programme needs to be initiated, targeting local community at various levels. This outreach programme should include topics such as the importance of birds as pest controllers and seed dispersers.

3.9 Phytoplankton (Pai Forest)

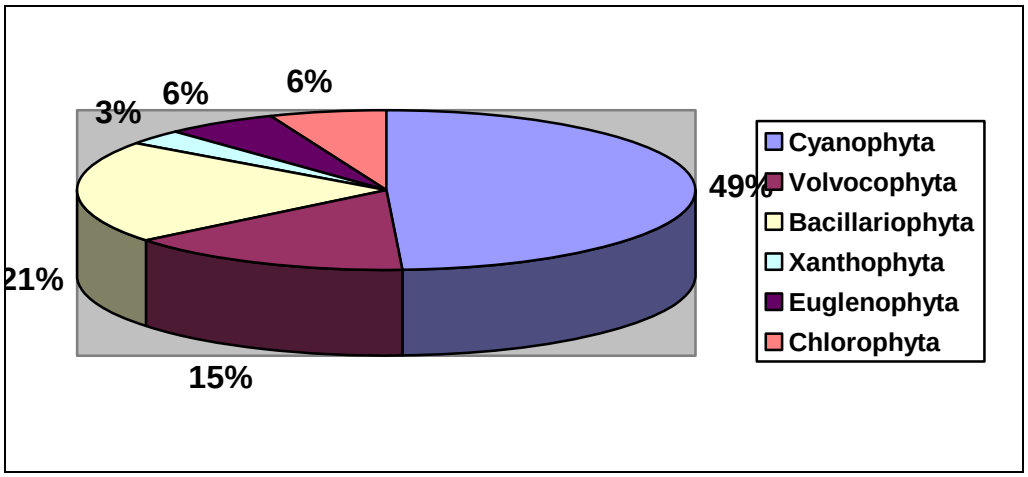
3.9.1 Summer Flora

Table 29 gives a summary of phytoplankton species recorded over the genera, family, order, class, phylum and kingdom. A total of 67 species were recorded during the summer survey. **Figure 21** shows the representation of species over phylum. The majority of species belong to the Cyanophyta phylum followed by Bacillariophyta and Volvocophyta.

Table 29 – Distribution of Algal Flora from Pai forest during summer

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	2	4	16	33
PROTISTA	Volvocophyta	2	3	4	7	10
	Bacillariophyta	1	1	5	8	14
	Xanthophyta	1	1	1	1	2
	Euglenophyta	1	1	1	2	4
PROTOCTISTA	Chlorophyta	1	2	2	2	4
3	6	8	11	17	32	67

Figure 21 – Percentage of species against phylum recorded in Pai forest (summer)



3.9.2 Discussion (summer)

In blue green algae 33 species belongs to 16 genera of phyla Cyanophyta. In which maximum number of the genus *Oscillatoria* (9) species secondly six species of the genus *Lyngbya* on thirdly 3 species of the genus *Chroococcus* from minimum number of one species of each genus *Aphanothece, Coelospherium, Gloeocapsa, Gloeothece, Microcystis, Phormidium, Anabaena, Nostoc, Shizothrix, Microcoleus, Hydrocoelus* and two species of the genus *Scytonema, Aphanocapsa* were recorded during field trip in summer season June 2007. Number of genera and their species are included in Epilithic/soil algal flora. Algal species indicate the top/best quality of soil in which genera and their species like *Lyngbya, Oscillatoria, Anabaena, Nostoc, Schizothrix, Scytonema, Microcoleus, Hydrocoelus* etc. these genera are included in hyterocystis group. They have capacity to fix nitrogen from atmosphere which is beneficial for plants and crops like maize, rice, and sugarcane etc. species of the genus *Aphanocapsa, Aphanothece, Coelospherium, Gloeothece, Microcystis* are included in toxic group and good indicator of polluted water. Waste material of animals, plants and their leaves disintegrate due to high temperature. All such material mix in water courses which is supplied to this area for use.

The quality of ground water is not as good as that of surface water and it varies considerably both vertically and horizontally in various parts of the country ranging from fresh to extremely saline (Kalown et al, 2003).

- **Green algae:** Ten species belongs to seven genera of Volvocophyta, three species of *Pediastrum,* two species of *Ankistrodesmus,* one species of each genus *Oocystis, Tetraedron, Chlorococcum, Scenedesmus, Chlorella* were recorded. The species of all these genera are used as delicious food for aquatic life. Species of *Pediastrum* and *Scenedesmus* indicate high ratio of chloride in water. *Chlorococcum humicola* was found in layer form; species of *Chlorella, Ankistrodesmus, Oocystis, and Tetraedron* are included in medicinal group and found as epiphytic group on Potamogeton. *Closterium minutum* is included in desmid group of hypolimnion flora. It was found mixed with other aquatic vegetation.

- **Golden brown algae:** 14 species belonging to 8 genera of class Bacillariophyceae were found in which three species of genus *Achnanthes,* on two species of *Navicula, Diatoma, Synedra, Nitzchia* each and one species of the genus *Fragilaria, Nedium, Gomphonema* were recorded. All these species of the genera are included among Epilithic/soil flora; species of *Nitzchia* are good indicator of polluted, hard water. It may cause diarrhea, vomiting, pain, headache. All the other species are good food for aquatic life. Species of the genus *Ophiocytium* belong to phyla Xanthophyta. It is also a good indicator for polluted and hard water.

- **Flagellales group:** 4 species of phyla Euglenophyta, two species of the genus *Euglena* and *Phacus* were recorded. All these species have flagella with the help of which they move easily within water body from one site to another site. The good habitat of these genera is saline and waste water, very few species were found due to scarcity of water.

- **Grass green algae:** 4 species of belonging to phyla Chlorophyta, one species of the genus *Cladophora* of class Siphonocladophyceae and three species of the genus *Spirogyra* were recorded. The species of genus *Cladophora* is cosmopolitan and common every where. It produces good food for aquatic fauna. This species was recorded from the temperature of water 6^{o}C to 32^{o}C from lotic and lentic water. This genus was also recorded from marine water.

Three species of the genus *Spirogyra* of class Zygnemophyceae were recorded. *Spirogyra* is a good indicator of alkaline water. In other countries *Spirogyra* is used as fodder for the cattle. It is mixed with cement for light weight in construction. In China and Japan people consume and know the importance of *Spirogyra* since 300 BC. This is also very common in our country. This genus was recorded from 4^{o}C to 38^{o}C of water temperature. This genus is very common through out the year. It produces mat which is dangerous for aquatic life, including fish and fauna etc. To remove the mat from water, mechanical method is needed to save the aquatic life. Chemical method can not be used because that all such aquatic life including fish fauna may be die. This genus was seen from April to October in upper Nultar pond near Lake where the temperature of water very low due to snow/glacier melting and this genus also was found in Pai forest in which water temperature was recorded high. This genus can create problem especially in fish hatchery by producing mat in which young animals are

entangled and die. At that time the mat has to be carefully removed to save the small fishes and their eggs and other aquatic life.

3.9.3 Winter Flora

Table 30 gives a summary of phytoplankton species recorded over the genera, family, order, class, phylum and kingdom. A total of 71 species were recorded during the winter survey. Out of the total 25 algal samples collected 71 species belonged to 34 genera of 7 phyla e.g. Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Euglenophyta, Chlorophyta, and Charophyta along with 17 aquatic plants.

Table 30 – Distribution of Algal Flora from Pai forest during winter

Kingdom		Phylum	Class	Order	Families	Genera	Species
MONERA		Cyanophyta	2	2	4	16	33
PROTISTA		Volvocophyta	2	3	4	8	11
		Bacillariophyta	1	1	5	8	14
		Xanthophyta	1	1	1	2	4
		Euglenophyta	1	1	1	2	4
PROTOCTISTA		Chlorophyta	1	2	2	2	4
		Charophyta	1	1	1	1	3
Total	**3**	7	9	12	18	34	71

3.9.4 Discussion (winter)

- **Blue green algae:** 33 species belonging to 16 genera of phyla Cyanophyta, the maximum 9 species of the genus *Oscillatoria,* 6 species of the genus *Lyngbya,* 3 species of genus *Chroococcus,* 2 species of the genus *Aphanocapsa* and *Scytonema*, one species of the each genus *Aphanothece, Coelospherium, Gloeocapsa, Gloeothece, Microcystis, Phormidium, Anabaena, Nostoc, Shizothrix, Microcoleus, Hydrocoelus,* etc. were recorded

- **Green algae:** 11 species belonging to 8 genera of the phyla Volvocophyta were observed. Maximum 3 species of the genus *Pediastrum*, one species of the each genus e.g. *Ankistrodesmus, Oocystis, Tetraedron, Chlorococcum, Scenedsmus, Chlorella, Closterium, Cosmarium*, were recorded.

- **Golden Brown algae:** 14 species belonging to 8 genera of the phyla Bacillariphyta. The maximum 3 species of the genus *Achnanthes*, two species of each genus e.g. *Navicula, Diatoma, Synedra, Nitzchia,* one species of the each genus *Gomphonema, Nedium, Fragilaria* were observed.

- **Xanthophyta:** 2 species belonging to one genus namely *Ophicytium* of the phyla Xanthophyta were recorded.

- **Flagellale group:** 4 species of the 2 genera of the phyla Euglenophyta. Two species of the each genus *Euglena* and *Phacus* were recorded; each species has flagella so they easily move in water body with the help of flagella.

- **Grass green algae:** 4 species belonging to two genera of the phyla Chlorophyta. The maximum three species of the genus *Spirogyra* and one

species of the genus *Cladophora* were recorded. *Cladophora* produce good food for aquatic life, itself used as fodder for the cattle, *Spirogyra* also used as fodder for the cattle, it is good indicator of the water for alkaline.

- **Charophyta:** 3 species belonging to one genus of the phyla Charophyta. *Chara* is excellent food producer species (ii) *Chara* has capacity to reduce hardness from water, (iii) *Chara* is good indicator for alkaline water, (iv) In presence of *Chara* 100% assurance that availability of fishes, (v) When *Chara* mature at that time smell from *Chara* to kill the mosquitoes.

3.9.5 Summer and winter comparison

Table 31 below shows the summer and winter results of phytoplankton recorded from Pai Forest.

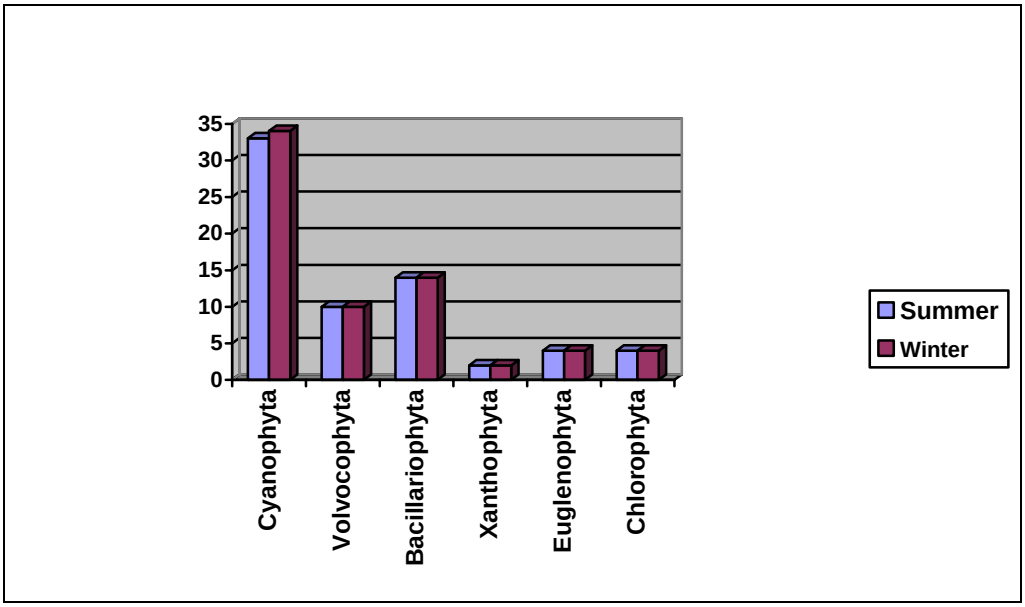
Table 31 – Distribution of algal flora from Pai forest during summer and winter

Name of Genera	Number of Species Summer	%	Number of Species winter	%
Kingdom: MONERA				
Phylum: Cyanophyta				
Class: Chroocophyceae				
Order: Chroococcales				
Family: Chroococcaceae				
1. *Aphanocapsa*	2	3	2	2.9
2. Aphanothece	1	1.5	1	1.43
3. Chroococcus	3	4.5	1	1.43
4. Coelospherium	1	1.5	3	4.3
5. Gloeocapsa	1	1.5	1	1.43
6. Gloeothece	1	1.5	1	1.43
7. *Microcystis*	1	1.5	1	1.43
Class: Nostocophyceae				
Order: Nostocales				
Family: Oscillatoriaceae				
8. Lyngbya	6	9	6	8.6
9. Oscillatoriea	9	13.4	9	12.9
10. Phormidium	1	1.5	1	1.43
Order: Nostocales				
Family: Nostocaceae				
11. Anabaena	1	1.5	1	1.43
12. Nostoc	1	1.5	1	1.43
Family: Rivulariaceae				
13. Shizothrix	1	1.5	1	1.43
14. Scytonema	2	3	2	2.9
15. Microcoleus	1	1.5	1	1.43
16. Hydrocoelus	1	1.5	1	1.43
Kingdom: PROTISTA				
Phylum: Volvocophyta				
Class: Volvocophyceae				
Order: Chlorococcales				

Family: Oocystaceae				
1. Ankistrodesmus	1	1.5	1	1.43
2. Oocystis	1	1.5	1	1.43
3. Tetraedron	1	1.5	1	1.43
Family: Chlorococcaceae				
4. *Chlorococcum*	1	1.5	1	1.43
Family: Hydrodictyaceae				
5. Pediastrum	3	4.5	3	4.3
Family: Scenedesmaceae				
6. *Scenedesmus*	1	1.5	1	1.43
Order: Chlorellales				
Family: Chlorellaceae				
7. *Chlorella*	1	1.5	1	1.43
Class: Desmidiophyceae				
Order: Desmidiales				
Family: Desmidiaceae				
8. Closterium	1	1.5	1	1.43
Phylum: Bacillariophyta				
Class: Bacillariophyceae				
Order: Biddulphiales				
Family: Achnanthaceae				
1. *Achnanthes*	3	4.5	3	4.3
Family: Gomphonemaceae				
2. Gomphonema	1	1.5	1	1.43
Family: Naviculaceae				
3. *Navicula*	2	3	2	2.9
4. Nedium	1	1.5	1	1.43
Family: Fragilariaceae				
5. *Fragilaria*	1	1.5	1	1.43
6. *Diatoma*	2	3	2	2.9
7. *Synedra*	2	3	2	2.9
Family: Nitzchiaceae				
8. *Nitzchia*	2	3	2	2.9
Phylum: Xanthophyta				
Class: Xanthophyceae				
Order: Mischococcales				
Family: Chlorobotrydaceae				
1. *Ophiocytium*	2	3	2	2.9
Phylum: Euglenophyta				
Class: Euglenophyceae				
Order: Euglenales				
Family: Euglenaceae				
1. *Euglena longicauda*	2	3	2	2.9
2. *Phacus*	2	3	2	2.9

Kingdom: PROTOCTISTA				
Phylum: Chlorophyta				
Class: Siphonocladophyceae				
Order: Cladophorales				
Family: Cladophoraceae				
1. Cladophora	1	1.5	1	1.43
Class: Zygnemophyceae				
Order: Zynemales				
Family: Zygnemaceae				
2. *Spirogyra*	3	4.5	3	4.3

Figure 22 – Number of species found in each phylum during summer & winter



3.9.6 Summer and winter discussion

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 and 25 algal sample 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, Charophyta along with 17 aquatic plants and some physico-chemical parameter were recorded, water is rich in primary productivity and plant production.

3.9.7 Threats and recommendations

No specific threats or recommendations were submitted by the consultant. However, the following comments were included as part of the conclusion: The quantity of algal species was better from summer flora even though the ground water was alkaline through out the forest. There is need for a detailed study in the area over a longer period using the latest equipments.

3.10 Phytoplankton (Keti Shah)

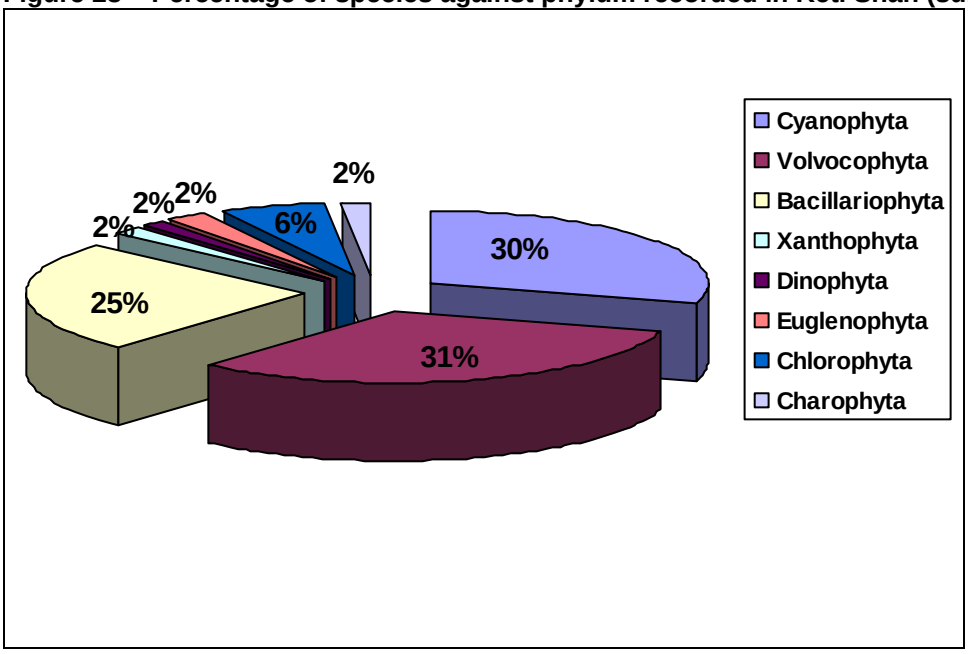
3.10.1 Summer Flora

Table 32 gives a summary of phytoplankton species recorded from Keti Shah over the genera, family, order, class, phylum and kingdom. A total of 128 species were recorded during the summer survey. **Figure 23** shows the representation of species over phylum. The majority of species belong to the Volvocophyta phylum followed by Cyanophyta and Bacillariophyta.

Table 32 – Distribution of phytoplankton/algal species in Keti Shah during summer

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	3	4	17	38
PROTISTA	Volvocophyta	2	5	9	17	41
	Bacillariophyta	1	2	8	15	32
	Xanthophyta	1	1	1	2	2
	Dinophyta	1	1	2	2	2
	Euglenophyta	1	1	1	2	3
PROTOCTISTA	Chlorophyta	2	4	6	6	8
	Charophyta	1	1	1	1	2
Total: 3	8	11	18	32	62	128

Figure 23 – Percentage of species against phylum recorded in Keti Shah (summer)



3.10.2 Discussion (summer)

- **Blue green algae:** 38 species (29.7%) belonging to 17 genera of phyla Cyanophyta were found. The genus *Oscillatoria* had 10 species, 6 species belonged to genus *Lyngbya,* 4 species of the genus *Phormidium,* two species of genera *Gloeocapsa, Merismopedia, Microcystis, Anabaena* each, one species of genus, *Aphanocapsa, Aphanothece, Chroococcus, Cyanarcus, Gloeothece, Gomphosphaeria, Pseudoholopedia, Aphanizeminon, Nostoc, Calothrix* each were represented.

  The species of the genus *Oscillatoria* are included in medicinal group and used to prepare vitamins. Species of the genera *Aphanocapsa, Aphanothece, Gloeothece, Microcystis, Aphanizeminon* are included in toxic group. Species of the genera *Anabaena, Aphinizeminon, Nostoc, Calothrix* are included in nitrogen fixing group. Species of *Lyngbya* and *Phormidium* are included in epiphytic and epilithic group. Species of the genera *Gloeocapsa, Merismopedia, Microcystis, Pseudoholopedia* are included in plankton group e.g. Eu, Phyto, Tycho, potomoplankton.

- **Green algae:** 41 species (32%) belonging to 17 genera of phyla Volvocophyta were found of which 10 species of the genus *Cosmarium,* 4 species of genus *Pediastrum, Scenedesmus,* 3 species of the genus *Chlorella,* 2 species of genus *Ankistrodesmus, Oocystis, Crucigena, Chlamydomonas, Closterium, Staurastrum, Pleurotaenium* each, and one species of each genus *Tetraedron, Coelastrum, Dictyospherium, Palmella, Tetraspora, Volvox* each, were recorded. The species of *Closterium, Cosmarium, Staurastrum, Pleurotaenium* are included in hypolimnion group. They are good indicator of calcium hardness; species of *Chlamydomonas, Palmella, Tetraspora, Chlorella* are included in medicinal group. Species of the genus *Crucigena, Scenedesmus, Pediastrum* are good indicator of chlorides. All the green algal species are used as food for aquatic fauna and fishes.

- **Golden Brown Algae:** 32 species (25%) belonging to 15 genera of class Bacillariophyceae were recorded, in 4 species of the genus *Cymbella, Synedra* 3 species of each genus *Achnanthes, Amphora, Gomphonema,* two species of the genus *Gyrosigma, Navicula, Surirella, Fragilaria, Nitzchia* and one species of each genus *Cocconics, Neidium, Pinnularia, Melosira* were recorded. One species of each genus *Botryococcus* and *Ophiocytium* of phyla Xanthophyta were found. One species each of genera *Ceratium* and *Peridinium* are represented. *Ceratium* is good indicator of low temperature of water and low ratio of salinity in the water.

- **Flagellales group:** In this group two species of *Euglena,* one species of *Phacus* and species *Chlamydomonas* are included. Their movement is with the help of flagella in water. *Euglena* was easily collected from corner side as tychoplankton.

- **Grass green algae:** Two species of the genus *Ulothrix, Oedogonium, Spirogyra* one species each of genera *Cladophora, Chaetophora* were recorded. They are easily identified with naked eyes with out microscope. They produce good food for aquatic fauna. Two species of *Chara* were found, they are excellent food producer species.

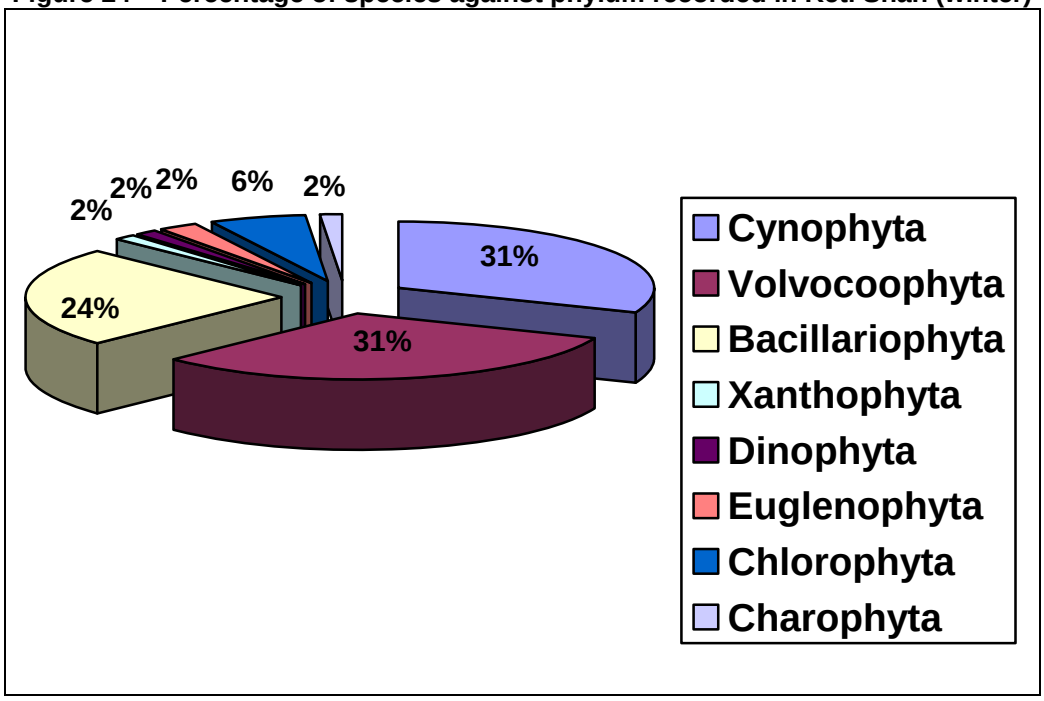
3.10.3 Winter Flora

Table 33 gives a summary of phytoplankton species recorded over the genera, family, order, class, phylum and kingdom. A total of 132 species were recorded during the summer survey. **Figure 24** shows the representation of species over phylum. The majority of species belong to the Volvocophyta phylum followed by and Cyanophyta and Bacillariophyta

Table 33 – Distribution of phytoplankton/algal species in Keti Shah during winter

Kingdom	Phylum	Class	Order	Family	Genera	Species
MONERA	Cyanophyta	2	3	4	17	41
PROTISTA	Volvocophyta	2	5	9	17	42
	Bacillariophyta	1	2	8	15	32
	Xanthophyta	1	1	1	2	2
	Dinophyta	1	1	2	2	2
	Euglenophyta	1	1	1	2	3
PROTOCTISTA	Chlorophyta	2	4	6	6	8
	Charophyta	1	1	1	1	2
Total: 3	8	11	18	32	62	132

Figure 24 – Percentage of species against phylum recorded in Keti Shah (winter)



3.10.4 Discussions

More than 50 algal samples were collected during November 2007 from Keti Shah Riverine area. A total of 132 algal species belonging to 61 genera of 8 phyla namely Cyanophyta, Volvocophyta, Bacillariophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta etc. were recorded.

- **Blue green algae:** 41 species belonging to 17 genera of the phyla Cyanophyta, in which maximum 10 species of the genus *Oscillatoria* next 6 species of the genus *Lyngbya,* 4 species of the genus *Phormidium*, 2 species of the each genus *Aphanocapsa, Chroococcus, Gloeocapsa, Merismopedia, Microcystis, Anabaena, Nostoc,* one species of the each genus *Aphanothece, Gloeothece, Gomphospheria, Pseudoholopedia,*

Aphanizeminon, Calothrix were represented. According to (Prescott 1962) in lakes, reservoir, etc. presence of *Microcystis, Merismopedia, Gloeocapsa, Oscillatoria* indicates the lake is Eutrophic. From riverine area collected all kinds of flora including fishes and fauna, low depth of water, high light transparency, stagnant water, low turbidity. The sunlight was shiny, day was clear, high ratio of dissolved oxygen, water was slightly alkaline. These conditions are favorable for the growth of flora and fauna including fishes. The abundance ratio of all the floras like phytoplankton, tychoplankton, potomoplankton, nano, Euplankton, Desmids, hypolimnion, metalimmion, epilimnion, epiphytic, epilith floras were collected. Presence of all these floras in water caused the colour of water to be gray green to dark green.

- **Green algae:** 42 species belonging to 17 genera of the phyla Volvocophyta. Maximum 10 species of the genus *Cosmarium*, next 5 species of the genus *Pediastrum,* 4 species of the genus *Scenedesmus,* 3 species of the genus *Chlorella,* 2 species of the each genus e.g. *Ankistrodesmus, Oocystis, Crucigenia, Chlamydomonas, Closterium,* one species of the each genus e.g. *Tetraedron, Coelastrum, Dictyospherium, Palmella, Tetrospora, Volvox,* were observed all these species are delicious food for aquatic life, *Chlorella, Chlamydomonas, Palmella,* are producing layer on the surface water and *Cosmarium, Closterium* produce layer on the bottom 1 cm above from the soil, the quantity wise all the species of these genera were observed high.

- **Golden brown algae:** 32 species belonging to 15 genera of the phyla Bacillariophyta. The maximum 4 species of each genus *Cymbella* and *Synedra,* 3 species of the each genus *Achnanthes, Amphora, Gomphonema,* 2 species of the each genus *Gyrosigma, Navicula, Surirella, Fragilaria, Nitzschia,* one species of the each genus *Cocconies, Neidium, Pinnularia, Diatoma, Melosira* etc. were represented. Diatoms are the basic and delicious food for aquatic life, fauna and fishes. Diatoms are full of oil. Fishes can easily digest chloroplast and oil, fish oil is full of vitamin A and D, Diatoms this group also used in toothpaste. Diatoms also used in solution, such solution used to polish the heavy metals. Diatoms also used to prepared small bricks, these bricks were used for sound and fire proof. Diatom solution also used in five star hotels to cleaning/shining the walls.

- **Xanthophyta:** 2 species belonging to 2 genera of the phyla Xanthophyta were recorded. One species of the each genus *Botryococcus* and *Ophiocytium* was found.

- **Dinophyta:** 2 species belonging to 2 genera of the phyla Dinophyta were recorded. One species of the each belonged to genus *Ceratium* and *Peridinium.* These species are very common in fresh water lakes, reservoirs. *Ceratium* indicate for low ratio of salinity and cold temperature. The species of *Ceratium* and *Peridinium* are included in metalimnion flora it means one meter below easily collected with the help of phytoplankton net.

- **Flagellales group:** 3 species belonging to 2 genera of the phyla Euglenophyta. 2 species of the genus *Euglena* and one species of the

genus *Phacus*. These species easily move with help of flagella in water. These species are very common in our region.

- **Grass green algae:** 8 species belonging to 6 genera of the phyla Chlorophyta. 2 species of the each genus *Ulothrix*, *Oedogonium, Spirogyra,* one species of the each genus *Cladophora, Chaetophora.* The species of *Ulothrix* and *Chaetophora* indicate for cold temperature of water, *Oedogonium* usually epiphytic group. *Spirogyra* found from corner side where water temperature slowly rise up. All the species are used as fodder for cattle. In mountainous area. Even in Chillas people collect this *Chaetophora* crushed, mix with oil and put on heat then put on the legs or arms where they feel pain for few hours and release pain from this treatment.

- **Charophyta:** 2 species of the one genus of the phyla Charophyta. *Chara* is excellent food producer species for aquatic life. It is good indicator for alkaline water. When *Chara* mature release smell such a smell to kills the larvae of mosquitoes. The effect of pH on water body was seems to be that as increase pH, increasing flora, fauna, fishes etc.

3.10.5 Summer and winter comparison

Table 34 gives a summary of phytoplankton species recorded over the genera, family, order, class, phylum and kingdom during summer and winter at Keti Shah.

Table 34 – Distribution of phytoplankton/algal species in Keti Shah (Indus) River during summer and winter

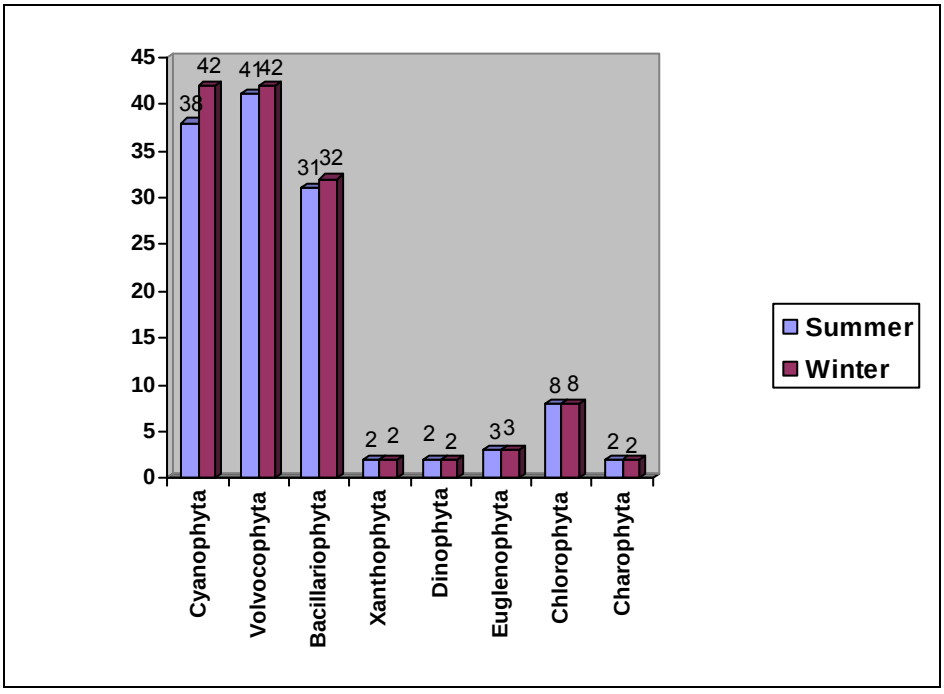
Number of genera	No. of Species Summer	%	No. of Species Winter	%
Kingdom: MONERA				
Phylum: Cyanophyta				
Class: Chroocophyceae				
Order: Chroococcales				
Family: Chroococcaceae				
1. *Aphanocapsa*	2	1.5	1	0.8
2. *Aphanothece*	1	0.8	1	0.8
3. *Chroococcus*	2	1.5	1	0.8
4. *Cyanarcus*	1	0.8	1	0.8
5. *Gloeocapsa*	2	1.5	2	1.6
6. *Gloeothece*	1	0.8	1	0.8
7. *Gomphosphaeria*	1	0.8	1	0.8
8. *Merismopedia*	2	1.5	2	1.6
9. *Microcystis*	2	1.5	2	1.6
10. *Pseudoholopedia*	1	0.8	1	0.8
Class: Nostocophyceae				
Order: Oscillatoriales				
Family: Oscillatoriaceae				
1. *Lyngbya*	6	4.6	6	4.7
2. *Oscillatoriea*	10	7.6	10	7.8
3. *Phormidium*	4	3	4	3.1
Order: Nostocales				

Family: Nostocaceae				
1. *Anabaena*	2	1.5	2	1.6
2. *Aphanizeminon*	1	0.8	1	0.8
3. *Nostoc*	2	1.5	1	0.8
Family: Rivulariaceae				
1. *Calothrix*	1	0.8	1	0.8
Kingdom: PROTISTA				
Phylum: Volvocophyta				
Class: Volvocophyceae				
Order: Chlorococcales				
Family: Oocystaceae				
1. *Ankistrodesmus*	2	1.5	2	1.6
2. *Oocystis*	2	1.5	2	1.6
3. *Tetraedron*	1	0.8	1	0.8
Family: Coelastraceae				
1. *Coelastrum*	1	0.8	1	0.8
Family: Dictyosphaeriaceae				
1. *Dictyospherium*	1	0.8	1	0.8
Family: Hydrodictyaceae				
1. *Pediastrum*	5	3.9	4	3.1
Family Scenedesmaceae				
1. *Crucigenia*	2	1.5	2	1.6
2. *Scenedesmus*	4	3	4	3.1
Order: Chlorellales				
Family: Chlorellaceae				
1. *Chlorella*	3	2.3	3	2.3
Order Tetrasporales				
Family: Palmellaceae				
1. *Palmella*	1	0.8	1	0.8
2. *Tetraspora*	1	0.8	1	0.8
Order: Volvocales				
Family: Chlamydomonadaceae				
1. *Chlamydomonas*	2	1.5	2	1.6
Family: Volvocaceae				
1. *Volvox*	1	0.8	1	0.8
Class: Desmidiophyceae				
Order: Desmidiales				
Family: Desmidiaceae				
1. *Closterium.*	2	1.5	2	1.6
2. *Cosmarium*	10	7.6	10	7.8
3. *Staurastrum*	2	1.5	2	1.6
4. *Pleurotaenium*	2	1.5	2	1.6
Phylum: Bacillariophyta				
Class: Bacillariophyceae				
Order: Biddulphiales				
Family: Achnanthaceae				
1. *Achnanthes*	3	2.3	3	2.3
2. *Cocconies*	1	0.8	1	0.8
Family: Cymbellaceae				
1. *Amphora*	3	2.3	3	2.3
2. *Cymbella*	4	3	4	3.1
Family: Gomphonemaceae				
1. *Gomphonema*	3	2.3	3	2.3
Family: Naviculaceae				
1. *Gyrosigma*	2	1.5	2	1.6

2. *Navicula*	2	1.5	2	1.6
3. *Neidium*	1	0.8	1	0.8
4. *Pinnularia*	1	0.8	1	0.8
Family: Surirelliaceae				
1. *Surirella*	2	1.5	2	1.6
Family: Fragilariaceae				
1. *Fragilaria*	2	1.5	2	1.6
2. *Diatoma*	1	0.8	1	0.8
3. *Synedra*	4	3	4	3.1
Family: Nitzschiaceae				
1. *Nitzschia*	2	1.5	2	1.6
Order: Centrales				
Family: Coscinodiscaceae				
1. *Melosira*	1	0.8	1	0.8
Phylum: Xanthophyta				
Class: Xanthophyceae				
Order: Mischococcales				
Family: Chlorobotrydaceae				
1. *Botryococcus*	1	0.8	1	0.8
2. *Ophiocytium*	1	0.8	1	0.8
Phylum: Dinophyta				
Class: Dinophyceae				
Order: Peridiniales				
Family: Ceratiaceae				
1. *Ceratium*	1	0.8	1	0.8
Family: Peridiniaceae				
1. *Peridinium*	1	0.8	1	0.8
Phylum: Euglenophyta				
Class: Euglenophyceae				
Order: Euglenales				
Family: Euglenaceae				
1. *Euglena*	2	1.5	2	1.6
2. *Phacus*	1	0.8	1	0.8
Kingdom: PROTOCTISTA				
Phylum: Chlorophyta				
Class: Ulvophyceae				
Order: Ulotrichales				
Family: Ulotrichaceae				
1. *Ulothrix*	2	1.5	2	1.6
Class: Siphonocladophyceae				
Order: Cladophorales				
Family: Cladophoraceae				
1. *Cladophora*	1	0.8	1	0.8

Order: Chaetophorales				
Family: Chaetophoraceae				
1. *Chaetophora*	1	0.8	1	0.8
Class: Zygnemophyceae				
Order: Oedogoniales				
Family: Oedogoniaceae				
1. *Oedogonium*	2	1.5	2	1.6
Order: Zygnemales				
Family: Zygnemaceae				
1. *Spirogyra*	2	1.5	2	1.6
Phylum: Charophyta				
Class: Charophyceae				
Order: Charales				
Family: Characeae				
1. *Chara*	2	1.5	2	1.6

Figure 25 – Number of species found in each phylum in summer & winter surveys



3.10.6 Conclusion

A total of 128 Algal species belongs to 62 genera of eight phyla were collected during in Keti Shah. A total of 38 species 29.7% belonging to 17 genera of phyla Cyanophyta, 41 species 32% belonging to 17 genera of phyla Volvocophyta, 32 species 25% belonging to 15 genera of phyla Bacillariophyta, 2 species 1.6% belonging to 2 genera of phyla Xanthophyta, 2 species 1.6% belonging to 2 genera of phyla Dinophyta, 3 species 2.3% belonging to 2 general of phyla Euglenophyta, 8 species 6.3% belonging to 6 genera of phyla Chlorophyta. 2 species 1.6% belonging to one genus of phyla Charophyta and more than 50 algal samples were collected during November 2007. A total of 132 algal species belonging to 61 genera of 8 phyla namely Cyanophyta, Volvocophyta,

Bacillariophyta, Xanthophyta, Dinophyta, Euglenophyta, Chlorophyta, Charophyta etc. were recorded, water is rich in primary productivity and plant production.

3.10.7 Threats and recommendations

No specific threats or recommendations were submitted by the consultant. However, the following comments were included as part of the conclusion: The Keti Shah river water is more productive in all respect and is eutrophic and alkaline recorded through out the River area. The flow, turbidity, rain, floods, all major factors affecting on the growth of the algal/phytoplankton vegetation. Thick algal/phytoplankton vegetation were accompanied by an increase in dissolved oxygen and pH. There is a need for a long term monitoring study using the latest equipment.

3.11 Zooplankton (Pai Forest)

3.11.1 Species account

The following invertebrates were captured and studied during the summer and winter surveys at Pai Forest include:

Phylum Arthropoda
Class Arachnida
Order Araneae
Suborder Neocribellatae
Family Thomisidae
Genus *Thomisus*

Image 17 – Thomisus species

Genus *Thomisus*

Seven specimens of Genus *Thomisus* were captured from the suburbs of the Pai forest.

Phylum Arthropoda
Class Arachnida
Order Araneae
Suborder Neocribellatae
Family Lycosidae
Genus *pardosa*

Image 18 – Pardosa species

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 leaves, moss and detritus. At Pai forest, four specimens of Genus

Thomisus were captured. The females belonging to the genus Pardosa were seen with their egg sacs attached to their spinners.

Phylum Arthropoda
Subclass Epimorpha
Order Scolopendromorpha
Family Scolopendridae
Genus *Scolopendra:*

Image 19 – Scolopendra

3.11.2 Discussion

A forest is a complex ecosystem made up of both living things such as trees and birds, and non-living things such as fallen logs, water and rock. The living parts of forest ecosystems form dynamic communities whose composition changes over time as a result of interacting and living together. All living things in the forest are part of a huge, complex and interacting web of life. Each living thing has its role in the health and growth of a forest.

Trees give a forest its overall structure but the animals that have the greatest influence on the health and appearance of the forest are invertebrates. The enormous variety of invertebrate animals include predators, that prey on other invertebrates; scavengers, that feed on dead animal and plant material and are vital in recycling nutrients through the forest and herbivores, that feed on fungi and living plants. All these in turn are food for birds, fish, reptiles, mammals and even some plants. Although they are so important in the forest ecosystem, most invertebrates are small, well hidden, or beautifully camouflaged and therefore easily missed.

Tropical forests are disappearing at alarming rates worldwide (Laurance, 1999). The loss and fragmentation of tropical forests appears to be the single greatest threat to the world's biological diversity (Whitmore, 1990; Huston, 1994). One of the resolutions of the Convention on Biological Diversity is that measures have to be taken in order to conserve natural forests, especially tropical forests, which are among the biodiversity hotspots considered as a global priority for conservation (Sayer and Wegge, 1992; Myers et al., 2000).

3.11.3 Threats and recommendations

No threats or recommendations were provided.

3.12 Zooplankton (Keti Shah)

3.12.1Species account

Not a single crustacean member belonging to any group was observed or captured during the winter and summer surveys at Keti Shah, showing the drastic effect of continuous influx of water on the micro invertebrate faunistic diversity and abundance in the in the forest and suburbs. Some arachnids were however captured and taxonomically investigated to belong to the following hierarchy:

- **Order Araneae**

  A number of spiders captured from the adjoining areas of Keti Shah were catalogued and identified at the genus level. Following is their taxonomic

hierarchy. There is a limited population of spiders in the places where the river water has not yet intruded.

- **Family: Lycosidae (Wolf Spiders)**
  Phylum: Arthropoda
  Class: Arachnida
  Order: Araneae
  Infraorder: Araneomorphae
  Family Lycosidae
  Genus *Pardosa*

3.12.2 Discussion

In addition to providing food for amphibians, reptiles, fishes, birds and mammals, a role, which they share with most other insects, beetles play other important roles in the environment. Many, cantharids, scarabs, byturids, and others, are pollinators). Dung beetles (scarabs, geotrupids, and others) feed on and reproduce in the dung of herbivores, thereby removing millions of tons of dung that would accumulate and destroy valuable pastureland and natural areas. Burying beetles (silphids) inter animal carcasses which are then used as food by the adults and their growing offspring thereby ridding the landscape of carcasses that would otherwise contaminate and foul the environment. Various nest-dwellers (including histerids, trogids, staphylinids) and fur ectoparasites (such as leiodids, leptinines) rid their bird and mammal hosts of parasitic insects, such as fleas, bed bugs, and lice. Some beetles are effective as bio-control agents, which predate plant-feeding insects. Among these are ladybug beetles (coccinellids), which feed on aphids and scale insects. The Vedalia ladybug beetle in California reduced the scourge of the cottony cushion scale (Icerya purchasi). Carabid beetles, such as the "caterpillar-hunters" (Calosoma, Carabus spp.) are often helpful in reducing populations of harmful caterpillars, such as gypsy moth and budworm caterpillars. Firefly larvae (glowworms) eat slugs and snails, which damage such crops as tomatoes and lettuce.

Most dragonflies and damselflies are regarded as beneficial insects because they feed on small flying insects such as mosquitoes. They may also catch and eat honey bees, and then they are regarded as pests by the beekeepers. In some parts of Europe, dragonflies are considered a threat to the poultry industry because they transmit *Prosthogoniums pellucidus*, a parasitic flatworm.

Dragonfly naiads become infected by ingesting cysts of the flatworm. These cysts survive into adulthood of the dragonfly and may spread to birds (particularly poultry) that catch and eat the adult dragonflies. The flatworm cysts dissolve in the bird's intestine and spreading infection into the cloaca and reproductive organs.

The Diptera probably have a greater economic impact on humans than any other group of insects. Some flies are pests of agricultural plants; others transmit diseases to humans and domestic animals. On the other hand, many flies are beneficial, particularly those that pollinate flowering plants, assist in the decomposition of organic matter, or serve as bio-control agents of insect pests.

3.13 Physico-chemical properties of water (Pai Forest)

3.12.1Sampling locations

Map 13 shows the sampling points of water quality sampling from Pai Forest. Further details of the sampling points can be found in the annexure document.

Map 13 – Sampling points of water quality at Pai Forest

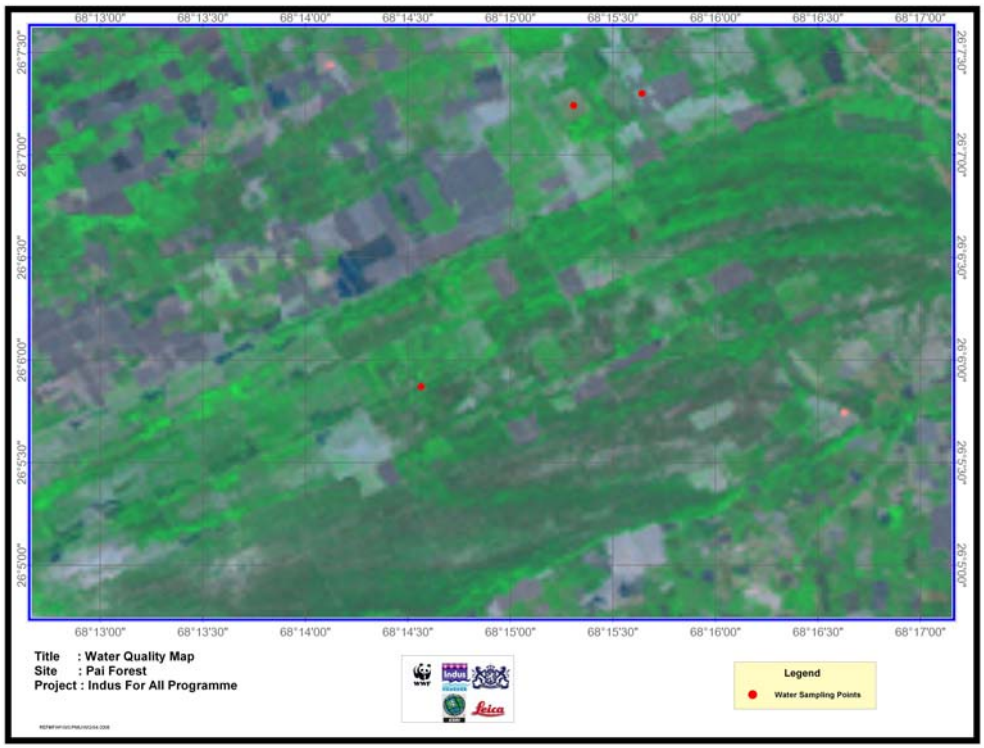


Table 35 – Significance of sample location points at Pai Forest Area

S.no	Sample number	Sample Location	Significance
1	PF-B1	Tube well at Chokri 15	Groundwater (GW) is the only source of water for the survival of the forest., this is also used for drinking It is important to judge GW quality
2	PF-B2	Tube well at Chokri	Test groundwater quality at the other end of the forest area.
3	PF-B3	Samano Rahoo Lake inside forest area	Lake being used for the fishery and livestock. Lake gets water not often from the canal water hence seepage water enters in to the lake and deteriorates the water quality

3.13.2 Field survey observation

Previously, Pai Forest was irrigated from Rohri Canal through the Rahib Shah Minor since 1946-47, to meet the shortage of wood fuel. Since the last seven years this precious source of surface water has been stopped, due to various reasons and plantation is surviving only on ground water supplied through the tube wells. Although there are 13 tube wells reported in the Pai Forest, only 7-8 tube wells are working. The 4 tube wells have also been installed in the newly started project by the Forest Department, Government of Sindh.

The encroachment and theft of irrigation water for local private farms are serious threats, which has resulted in drought and erosion in the vast area (1933 ha) of Pai Forest.

The samples were collected from Pai Forest command area and Keti Shah Forest which includes groundwater, lake water and River Indus water. For the Pai Forest groundwater is now the only source of survival of the forest, whereas, Keti Shah Forest gets frequent water from the River Indus. The samples were collected pre

monsoon (July 2007) and post monsoon (October/November 2007. However, the samples for the Keti Shah Forest were collected only post monsoon period.

Table 36 – Physical and chemical parameters (pre-monsoon)

S.no	Parameters	Pre monsoon
1	Temperature	30-32°C.
2	Electrical Conductivity	772-810 µS/cm.
3	TDS	490-519 ppm.
4	pH	7.62-8.47
5	Turbidity	4.04-188 NTU
6	Total Hardness	190-250 ppm
7	Calcium	110-170 ppm
8	Magnesium	140 ppm.
9	Sulphate	75-175 ppm.
10	Chlorine	29.8-97.3 ppm
11	Alkalinity	40-110 ppm.
12	Phenols	8.5-17ppb
13	Cr	53.92-56.02 ppb
14	Pb	23.70-27.50 ppb.
15	Cd	20.05-21.77 ppb.
16	Ni	17.05-19.75 ppm
17	Arsenic	30-77 ppb

Table 37 – Physical parameter and chemical parameters of Pai Forest (post-monsoon)

	Parameters	Post monsoon
1	**Temperature**	25-29°C.
2	**Electrical Conductivity**	760-3430 µS/cm
3	**TDS**	495-2196 ppm
4	**pH**	7.43-7.94
5	**Turbidity**	3.10-833 NTU
6	**Total Hardness**	150-444 ppm
7	**Calcium**	75-144 ppm
8	**Magnesium**	75-300 ppm
9	**Sulphate**	100-1150 ppm
10	**Chlorine**	55-350 ppm
11	**Alkalinity**	73-123 ppm.
12	**Phenols**	8.5-51.0 ppb
13	**BOD**	2.01-34.12 ppm
14	**COD**	5.05-37.92 ppm
15	**Cr**	23.3-53.9 ppb
16	**Pb**	9.65-13.06 ppb.
17	**Cd**	0.28-0.98 ppb.
18	**Ni**	3.48-27.9 ppm
19	**Arsenic**	25-75 ppb

3.13.3 Drinking Water

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.

3.13.4 Agriculture and livestock

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.

3.13.5 Fisheries

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

3.13.6 Conclusion

Tables 38 to 40 show the results against permissible WHO standards and are supported by remarks against each parameter.

Table 38 – Pai Forest water quality assessment (Pre Monsoon (Groundwater)

S.no	Parameter	Permissible WHO standards	PF-B1	PF-B2	Remarks
1	TDS (mg/l	1000	495	490.0	Normal
2	pH	6.5-8.5	7.62	7.85	Normal
3	Turbidity (NTU)	5	4.04	4.15	Normal
4	Total Hardness (mg/l)	500	250±0.1	155±0.05	Normal
5	SO_4 (mg/l)	250	75±0.05	190±0.22	Normal
6	Cl (mg/l)	250	29.8±0.05	55±0.05	Normal
7	Magnesium (mg/l)	150	140±0.15	77±0.2	Normal
8	Calcium (mg/l)	75	110±0.15	78±0.20	Slightly high in PF-B1
9	Phenol (µg/l)	0.002 mg/l	17.0	9.0	High
10	Cr (µg/l)	0.05 mg/l	53.92	25.0	Normal
11	Cd (µg/l)	0.003 mg/l	20.05	0.30	High
12	Pb (µg/l)	0.01 mg/l	27.50	13.0	PF-B 1 slightly high
13	Ni (mg/l)	0.02 mg/l	17.05	5.3	Slightly high in PF-B1
14	As (µg/l)	0.01 mg/l (10 (µg/l)	30	77	High

The ± values show the standard deviation

Table 39 - Pai Forest water quality assessment (post-monsoon groundwater)

S.no	Parameter	Permissible WHO, etc Standards	PF-A1	PF-A2	Remarks
1	TDS (mg/l	1000	487.0	495.0	Normal
2	pH	6.5-8.5	7.72	7.94	Normal
3	Turbidity (NTU)	5	3.10	4.10	Normal
4	Total Hardness (mg/l)	500	200±0.05	150±0.05	Normal
5	SO_4 (mg/l)	250	100±0.15	180±0.22	Normal
6	Cl (mg/l)	250	55±0.05	60±0.05	Normal
7	Magnesium (mg/l)	150	88±0.2	75±0.2	Normal
8	Calcium (mg/l)	75	112±0.2	75±0.20	Slightly high in PF-A1
9	Phenol (µg/l)	0.002 mg/l	8.5	8.5	Slightly High
10	Cr (µg/l)	0.05 mg/l	9.69	23.3	Normal
11	Cd (µg/l)	0.003 mg/l	0.28	0.35	Normal
12	Pb (µg/l)	0.01 mg/l	9.65	13.06	Normal
13	Ni (mg/l)	0.02 mg/l	3.48	5.18	Normal
14	As(µg/l)	0.01 mg/l (10 µg/l)	25	75	High

The ± values show the standard deviation

Table 40 – Pai Forest water quality assessment (pre and post monsoon Samano Rahoo Lake water)

S.no	Parameter	Permissible WHO Standards	PF-B3	PF-A3	Remarks
1	TDS (mg/l	1000	519	2196	PF-A3 very high
2	pH	6.5-8.5	8.47	7.43	normal
3	Turbidity (NTU)	5	188	833	high
4	Total Hardness (mg/l)	500	190±0.05	444±0.05	Near upper limit in PF-A3
5	SO4 (mg/l)	250	175±0.07	1150±0.15	PF-A3 very high
6	Cl (mg/l)	250	97.3±0.03	350±0.05	PF-A3 high
7	Magnesium (mg/l)	150	140±0.11	300±0.2	PF-A3 high
8	Calcium (mg/l)	75	50±0.11	144±0.2	PF-A3 high
9	Phenol (µg/l)	0.002 mg/l	8.5	51.0	high
10	Cr (µg/l)	0.05 mg/l	56.02	53.9	normal
11	Cd (µg/l)	0.003 mg/l	21.77	0.98	high
12	Pb (µg/l)	0.01 mg/l	23.70	10.6	PF-B3 Slightly high
13	Ni (mg/l)	0.02	19.75	27.9	Very high

The ± values show the standard deviation

3.13.7 Threats and recommendations

3.13.7.1 Threats

- The groundwater quality of Pai Forest is well within the acceptable WHO Drinking Water Quality Guidelines except Arsenic, which is toxic and detrimental to the health of people. In fact this is found naturally and relates with the geological formation of the soil.

3.13.7.2 Recommendations

- It is therefore recommended that people living and using this water should be aware of this toxic metal and its dangers for the health of all people specially the children and old age people;

- Further, it is suggested that the filters developed by researchers at Massachusetts Institute of Technology (MIT), Environment and Public Health Organization (ENPHO) of Nepal, and Rural Water Supply and Sanitation Support Programme (RWSSSP) of Nepal, may be introduced in the area to protect them from Arsenic hazards. Nevertheless, this groundwater is good for crops and all type of forestry and livestock;

- Samano Rahoo Lake is the only lake supporting the livestock, wildlife and fisheries in the forest. This lake and the forest require assured water

supply to protect the natural habitat. The supply through tube wells is not a sustainable solution hence canal supply needs to be ensured.

3.14 Physico-chemical properties of water (Keti Shah)

3.14.1Field survey observation

Keti Shah Forest is a riverine forest upstream of Sukkur Barrage receives frequent supply of water through River Indus. The drinking source of water is groundwater through shallow tube wells (Hand pumps) having bore depth up to 15 m. The livelihood is mostly agriculture, livestock and fisheries. From the discussion with people it was learnt that there are several small lakes around the forest area which gets water from the River Indus when it is flowing above normal level. (Here normal level is considered when there is no rainfall at upstream and river flows only for canal supplies). It is very hard to move freely in the forest because it is thickly planted and the houses located at various places which needs permission, before moving inside, from the local community living in the forest.

Table 41 – Physical parameter and chemical parameters (Post monsoon)

S.no	Parameters	Post monsoon
1	Temperature	25-29^{o}C.
2	Electrical Conductivity	287-427µS/cm.
3	TDS	184-274 ppm
4	pH	7.50-7.80
5	Turbidity	1.50-400 NTU
6	Total Hardness	60-120 ppm
7	Calcium	30-80 ppm
8	Magnesium	30-47 ppm
9	Sulphate	10-55 ppm.
10	Chlorine	24-54 ppm
11	Alkalinity	35-70 ppm
12	Phenols	8.5-8.5ppb
13	BOD	1.26-1.52 ppm
14	COD	8.85-19.10 ppm
15	Cr	8.99-15.9 ppb
16	Pb	21.31-33.85 ppb.
17	Cd	1.95-5.75 ppb
18	Ni	0.82-1.73 ppm
19	DO	1.4 -2.3 ppm

3.14.2 Drinking Water

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.

3.14.3 Agriculture and livestock

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.

3.14.4 Fisheries

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 (1977).

3.14.5 Conclusion

Tables 42 to 43 show the results against permissible WHO standards and are supported by remarks against each parameter.

Table 42 - Keti Shah Forest water quality assessment (post-monsoon groundwater)

S.no	Parameter	Permissible WHO, etc Standards	KTS-A1	KTS-A2	Remarks
1	TDS (mg/l	1000	268.0	274.0	Normal
2	pH	6.5-8.5	7.70	7.8	Normal
3	Turbidity (NTU)	5	5.0	1.50	Normal
4	Total Hardness (mg/l)	500	120±0.20	117±0.20	Normal
5	SO_4 (mg/l)	250	10±0.22	15±0.22	Normal
6	Cl (mg/l)	250	44±0.25	54±0.26	Normal
7	Magnesium (mg/l)	150	40±0.5	47±0.55	Normal
8	Calcium (mg/l)	75	80±0.50	70±0.55	Normal
9	Phenol (µg/l)	0.002 (mg/l)	8.5	8.5	Slightly high
10	Cr (µg/l)	0.05 (mg/l)	8.99	11.1	Normal
11	Cd (µg/l)	0.003 (mg/l)	4.15	5.75	Slightly high
12	Pb (µg/l)	0.01 (mg/l)	29.44	33.85	Slightly high
13	Ni (mg/l)	0.02 (mg/l)	1.60	0.82	Normal

The ± values show the standard deviation

Table 43 - Keti Shah Forest water quality assessment (post-monsoon surface water)

S.no	Parameter	Permissible WHO, etc Standards	KTS-A3 Shah Belo lake	KTS-A4 Indus river at Sukkur	Remarks
1	TDS (mg/l	1000	184.0	187.0	Normal
2	pH	6.5-8.5	7.5	8.1	Normal
3	Turbidity (NTU)	5	400	180	High
4	Total Hardness	500	65±0.15	60±0.20	Normal

	(mg/l)				
5	SO_4 (mg/l)	250	35±0.26	55±0.25	Normal
6	Cl (mg/l)	250	24±0.20	30±0.33	Normal
7	Magnesium (mg/l)	150	35±0.50	30±0.25	Normal
8	Calcium (mg/l)	75	30±0.50	30±0.25	Normal
9	DO(mg/l)	>2mg/l*	1.4	2.3	low
10	COD(mg/l)		8.85	19.10	Slightly high
11	BOD (mg/l)		1.26	1.52	Normal
12	Phenol (µg/l)	0.002(mg/l)	8.5	8.5	Slightly high
13	Cr (µg/l)	0.05(mg/l)	18.2	15.9	Normal
14	Cd (µg/l)	0.003(mg/l)	2.12	1.95	Normal
15	Pb (µg/l)	0.01(mg/l)	21.31	14.61	Slightly high
16	Ni (mg/l)	0.02(mg/l)	0.93	1.73	Normal

* Pescode 1977.

The ± values show the standard deviation

3.14.6 Threats and recommendations

No specific threats or recommendations were submitted by the consultant. The concluding remarks were that the ground water and surface water quality of Keti Shah Forest project area is well within acceptable limits of WHO Drinking Water Quality Guidelines. This water can be comfortably used for all purposes i.e., drinking, agriculture, livestock and fisheries.

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. 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 44** lists all the species recorded over the survey period.

Table 44 – Species recorded from different sites

Sr. 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 45**.

Table 45 – 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 46** below.

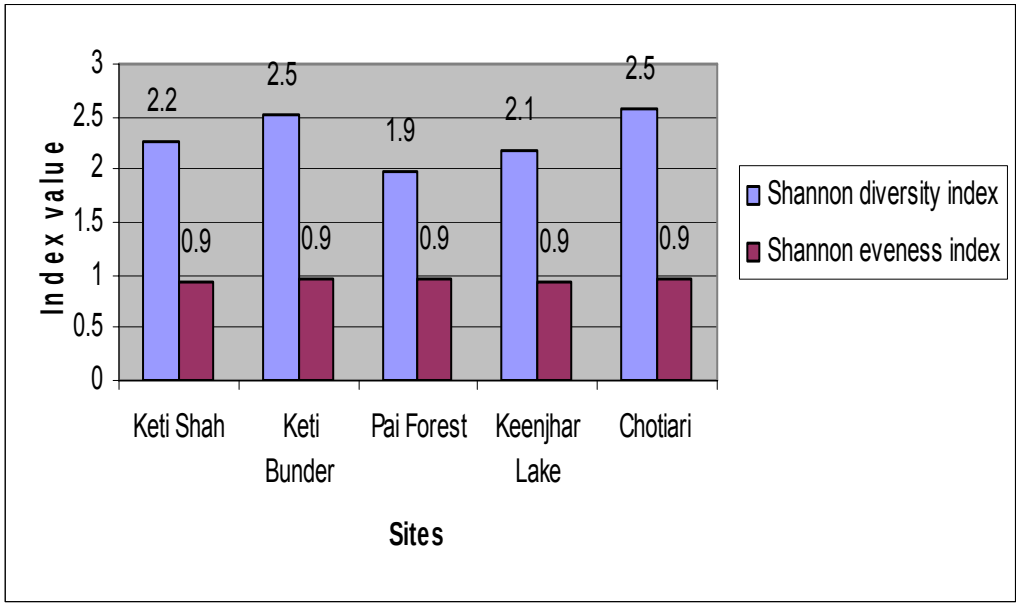
Table 46 – Conservation status of mammals found at Indus for All Programme sites

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 26**) 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 26 – 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 47 to 51**). 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 47 – 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 48 – Mammals recorded from Chotiari 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 49 – 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

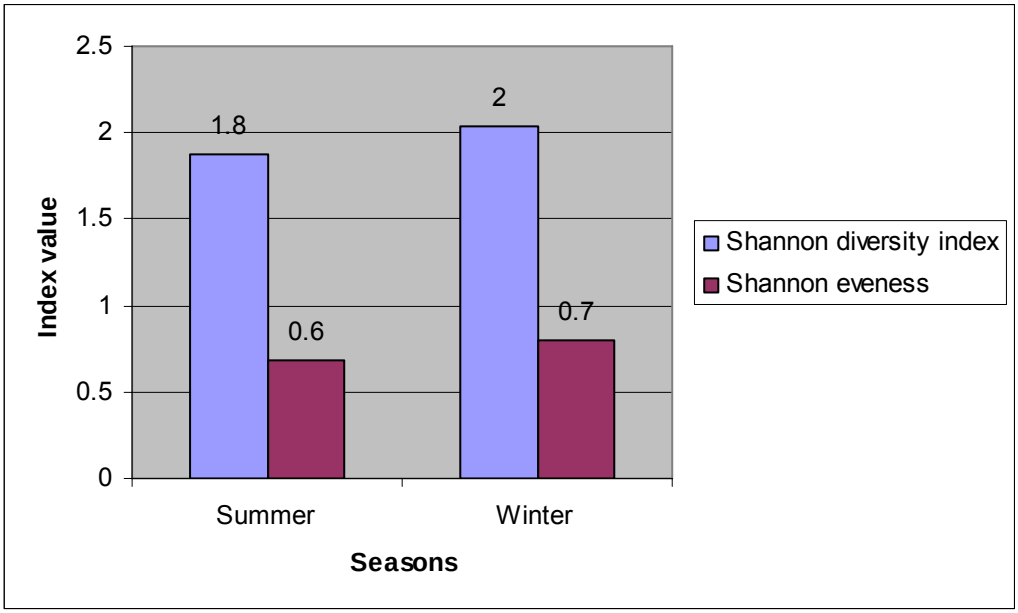
Table 50 - Mammals recorded from Keenjhar Lake during summer and winter surveys

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 51 – 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 27 – 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, three from Keenjhar one from Keti Bunder and two from Keti Shah. Estimated populations are given in the **Table 52 and 53**.

Table 52 – Estimated population of species found at the five sites

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

Table 53 – Estimated population of species found at the five sites

S.no	Site name	Bengal Fox	Small Indian Mongoose	Grey mongoose	Indian Otter	Chinkara	Hump-backed Dolphin
1	Keti Bunder	n/a	n/a	n/a	n/a	n/a	62
2	Keenjhar Lake	n/a	n/a	n/a	n/a	n/a	n/a
3	Chotiari Reservoir	n/a	n/a	n/a	12	5	n/a
4	Pai Forest	5	40	27	n/a	n/a	n/a
6	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

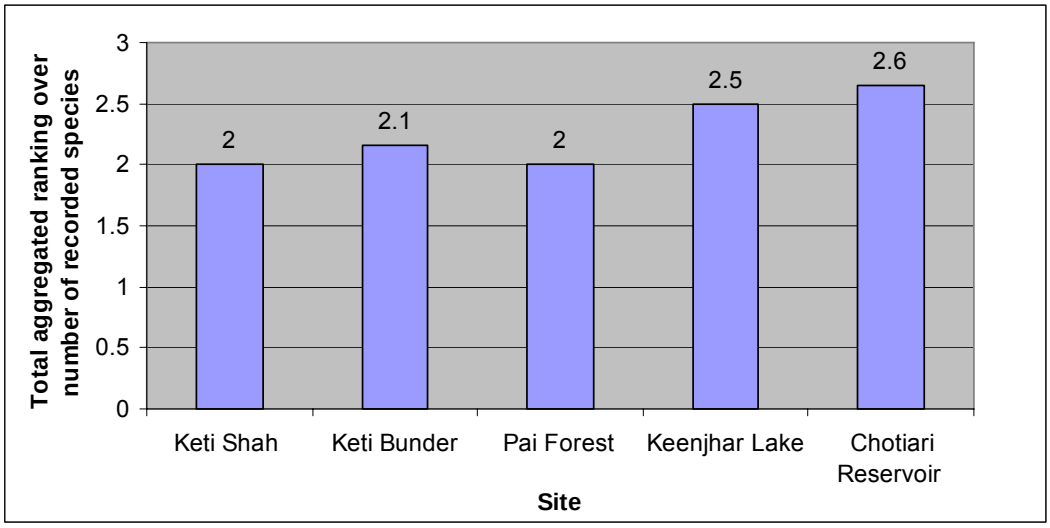
Various threats to different mammals were identified at five different study sites that include; habitat destruction, illegal hunting, poaching, live trapping, food competition, lack of awareness, law and order situation, weak enforcement of wildlife laws etc. Based on indirect and direct observations 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 54 – Assessment of level of threats to mammals at different study sites

S.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 28 – Aggregated threat ranking adjusted against number of species recorded from each site

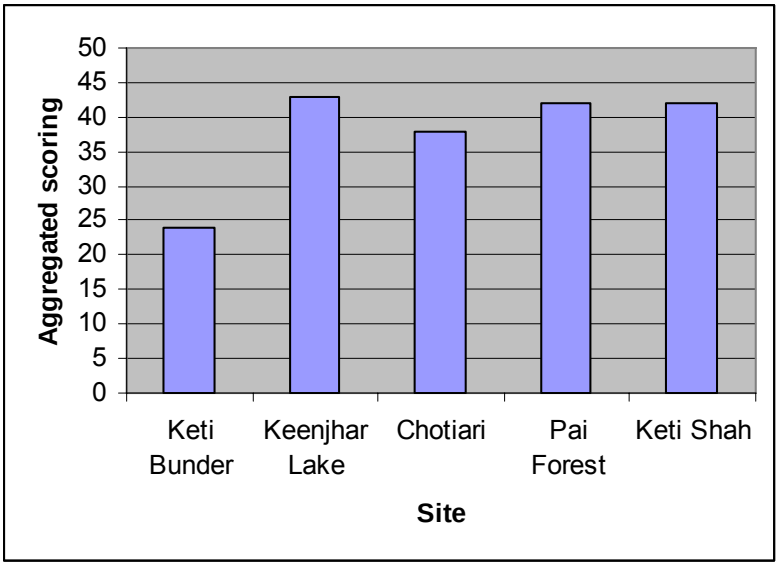


Chotiari Reservoir and Keenjhar Lake had the highest averaged disturbance factor against the species that were recorded there. Though this is an arbitrary scoring it does give an indication over the overall threat to large mammals at each site. Looking at general issues over the sites, Table 41 lists all the potential threats and attributes scores to them (ranging from 1 to 5, see legend below **Table 55**) across the sites. **Figure 29** gives the aggregated score for all sites.

Table 55 – Threats ranking for large mammals at sites

S. No.	Nature of Threats	Keti Bunder	Keenjhar Lake	Chotiari	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 29 – 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

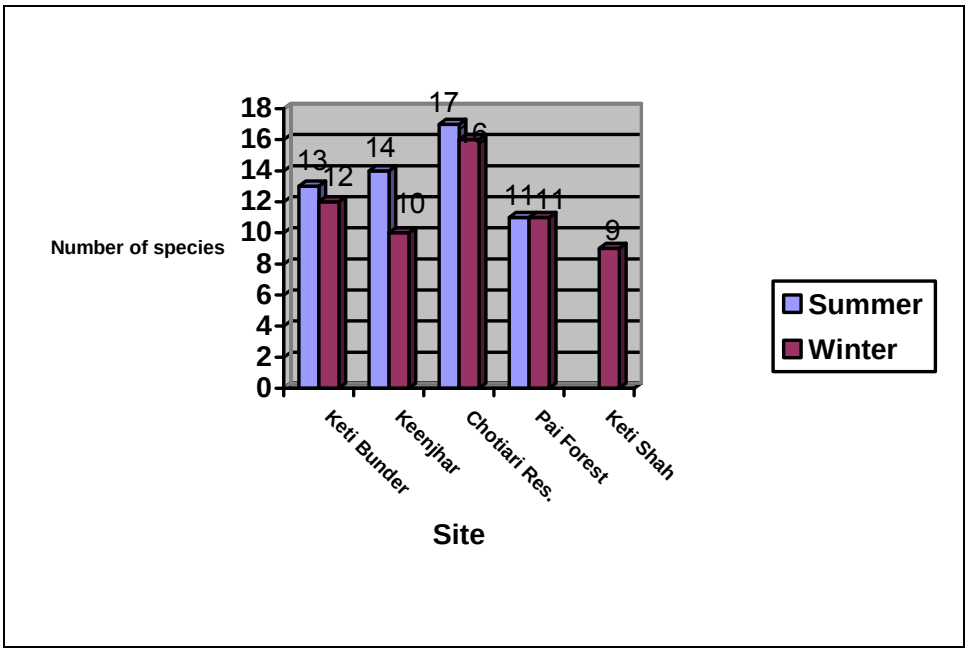
A total of 23 small mammal species were observed or collected from the five sites of the Indus for All Programme, 15 from Keti Bunder, 17 from Keenjhar, 19 from Chotiari, 14 from Pai forest and 9 from Keti Shah riverine forest. Most of these species were recorded in summer. The table (**Table 56**) below gives an account of species found at each site.

Table 56 – Total species recorded at five sites over summer and winter

	English Name	Scientific Name	Keti Bunder		Keenjhar		Chotiari		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 heathii*	-	-	-	-	+	-	+	-	-	-
22	House shrew	*Suncus murinus*	+	+	-	-	+	+	-		-	+
23	Indian Gerbil	*Tatera indica*	+	+	+	+	+	+	+	+	-	+

Figure 30 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 30 – Comparison of number of small mammal species over summer and winter



4.2.2 Similarity index over sites and seasons

Figure 31 and **32** 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 31 – Similarity index over five programme site during summer

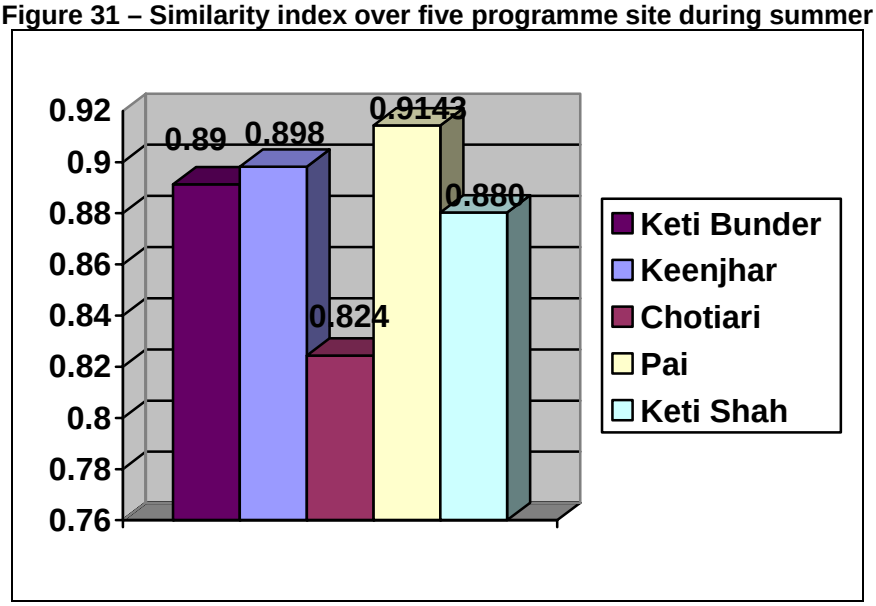
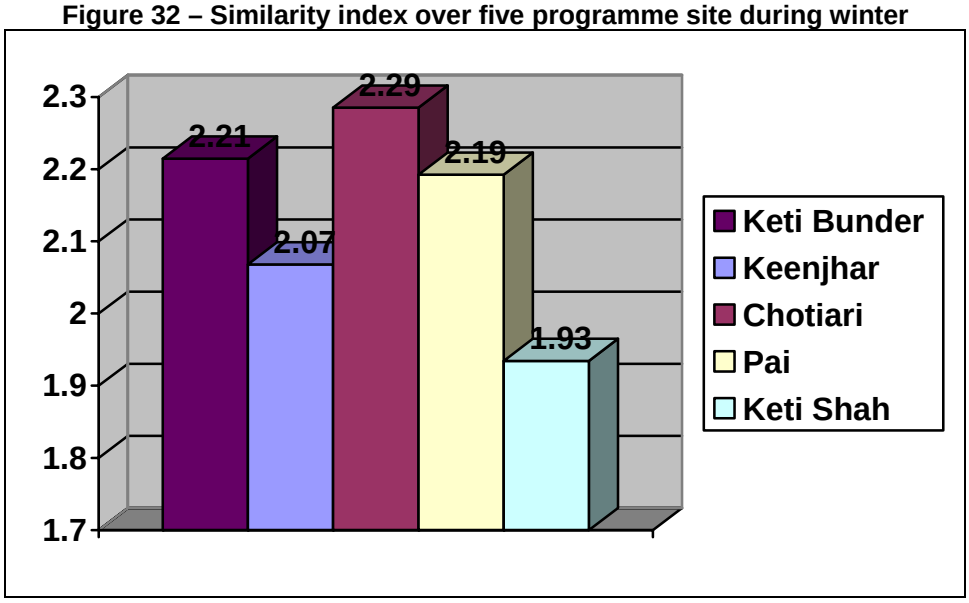


Figure 32 – Similarity index over five programme site during winter



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 33 and 34** give details of the percentage of species in each site against the main feeding habits.

Figure 33 – Percentage of species recorded for each site over feeding habit

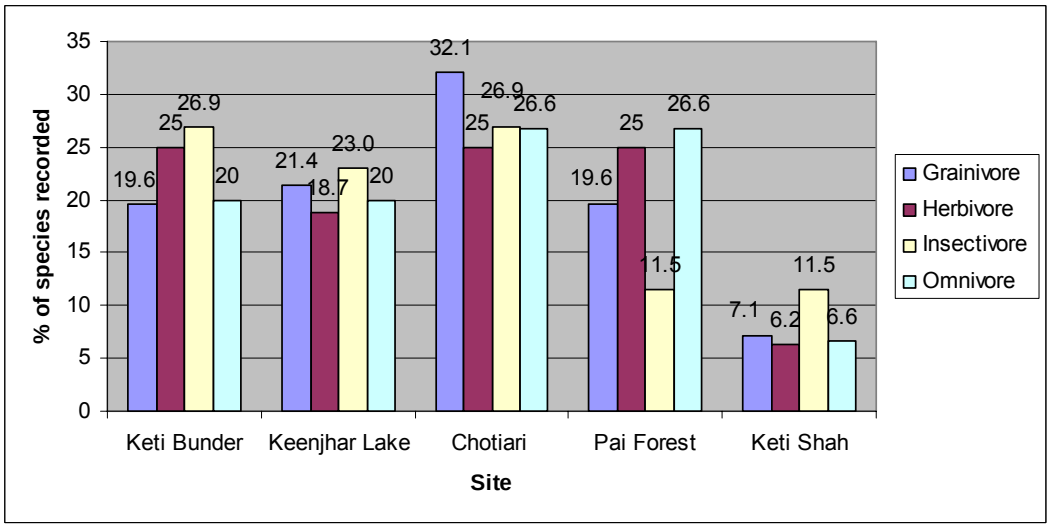
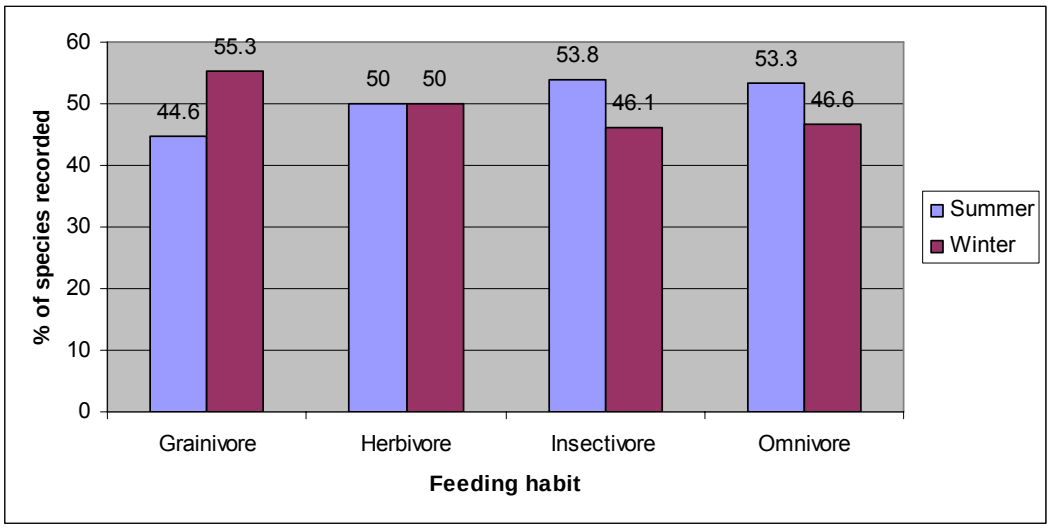


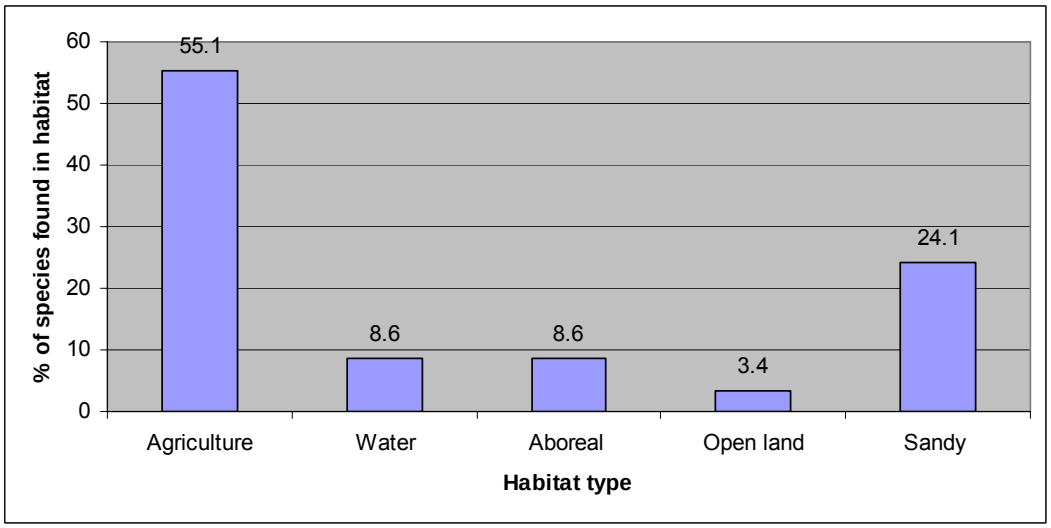
Figure 34 – Percentage of species recorded over season and against feeding habits



4.2.3 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 35** 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 35 – Number of species observed according the habitat



4.2.4 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 36 and 37** show the results over site and season.

Figure 36 – Percentage of species recorded across sites against status categories

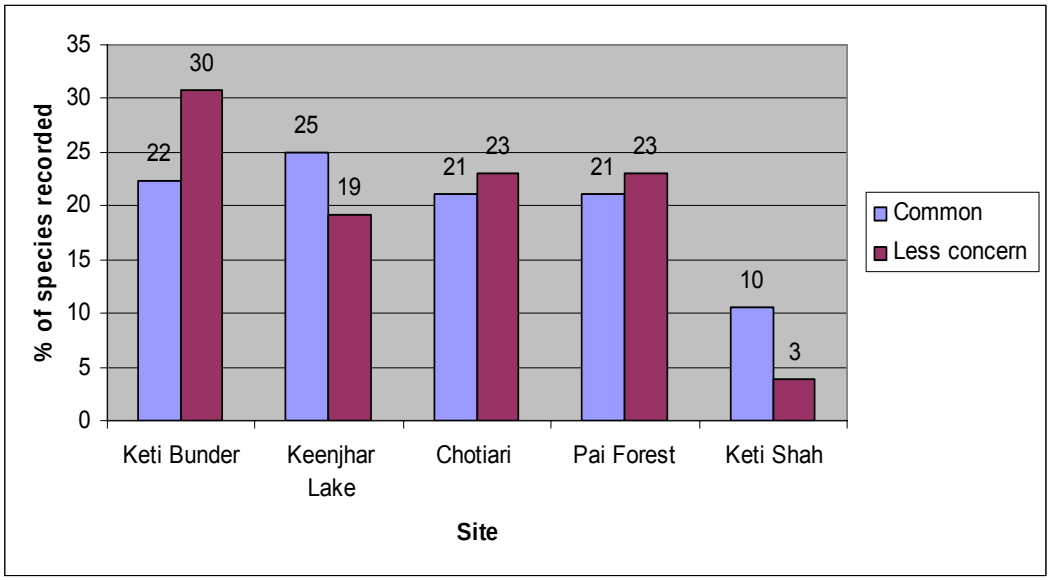
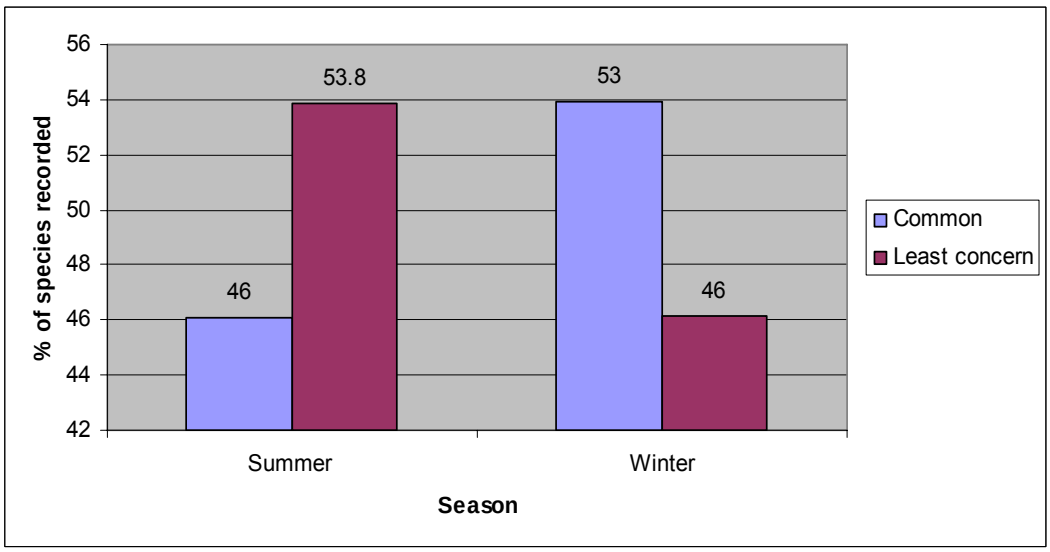


Figure 37 – Percentage of species recorded across season against status categories



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 Indus for All Programme 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 57.**

Table 57 – Amphibian and reptilian diversity among sites (Figures are number of individuals observed/collected)

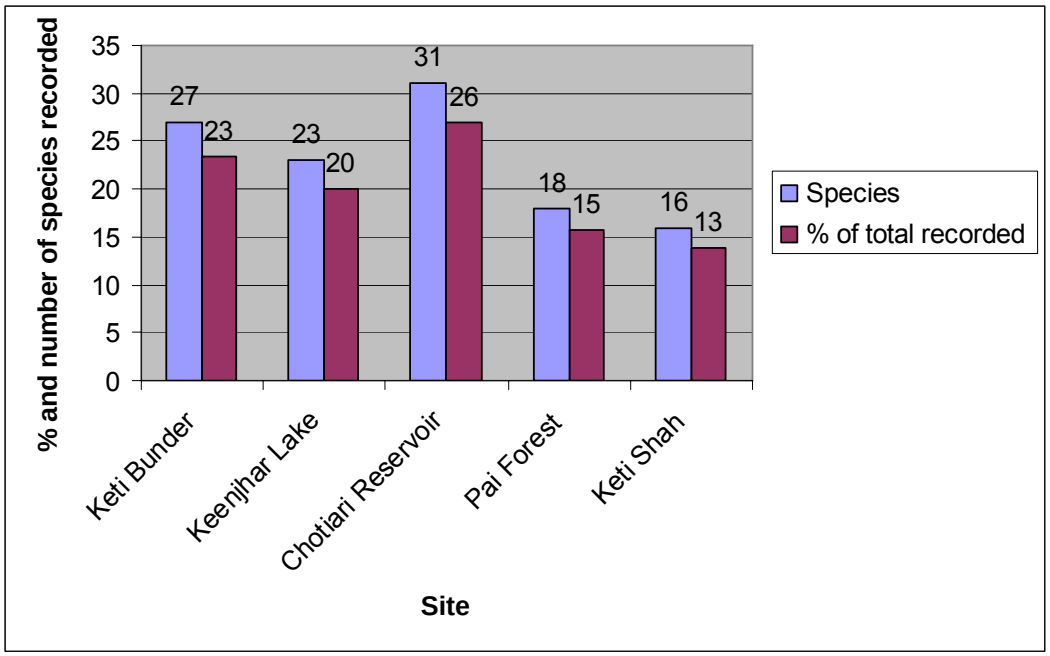
S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
1	*Bufo stomaticus*	387	117	74	139	42	15
2	*Euphlyctis c. cyanophlyctis*	138	39	32	47	20	0
3	*Hoplobatrachus tigerinus*	126	31	50	33	08	04
4	*Kachuga smithi*	128	0	0	66	0	62
5	*Kachuga tecta*	33	0	0	14	0	19
6	*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.*	07	0	07	0	0	0

S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
	kachhense						
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

S. No.	Species Name	Total	Keti Bunder	Keenjhar Lake	Chotiari Reservoir	Pai Forest	Keti Shah
57	*Spalerosophis atriceps*	08	04	04	0	0	0
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 38 – 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 48** 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 58 – 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 39 – Evenness of reptile and amphibian species across sites

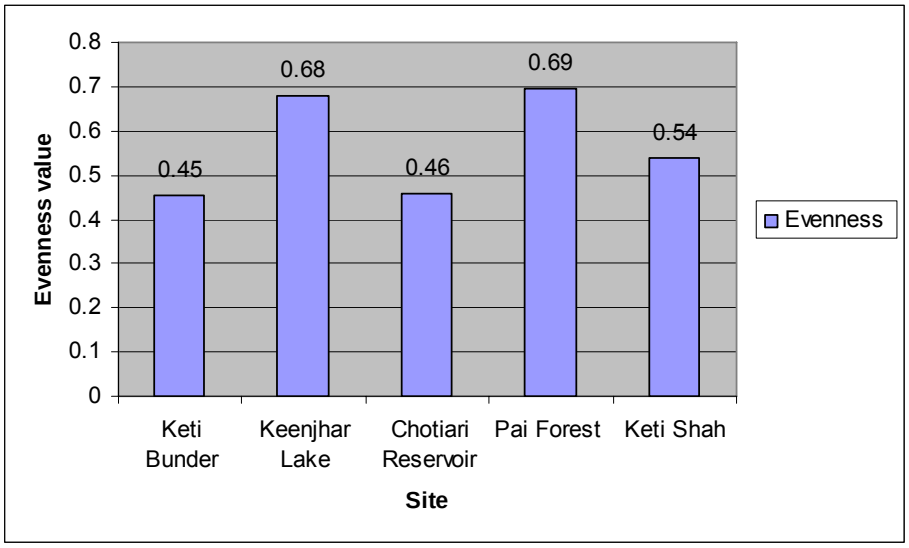
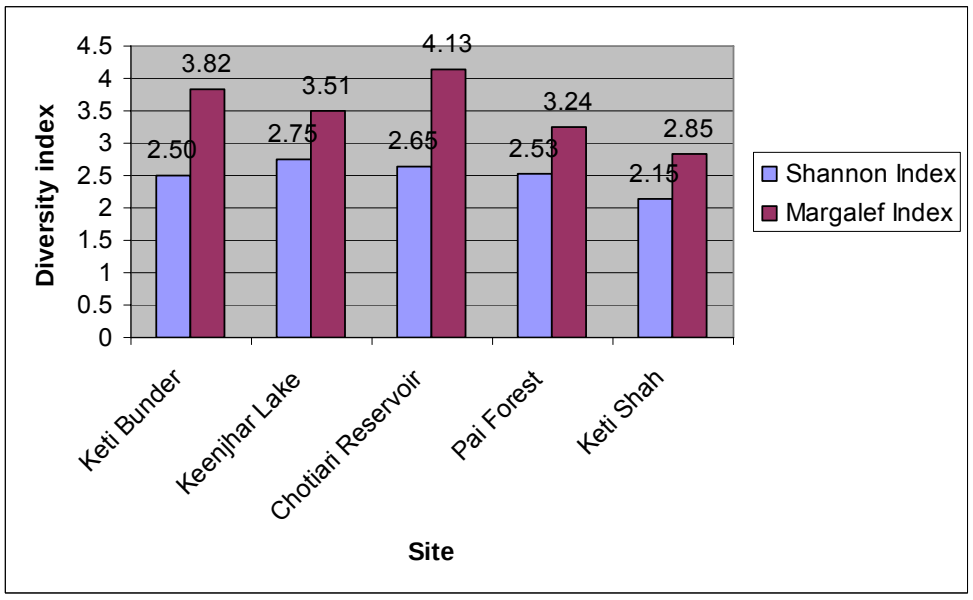


Figure 40 – Shannon and Margalef index for reptile and amphibian species for all sites



In the Margalef index Chotiari Reservoir shows the highest level of diversity whereas the Shannon 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 Birds

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 bird's 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 area. 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 59.**

Table 59 – Total number of bird species recorded at each site

S. No.	Total No. of Species recorded on Each Site	No. of Species
1.	Chotiari 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 60 – List of bird species recorded from each site

	Common Name	Keenjhar		Keti		Chotiari		Pai		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

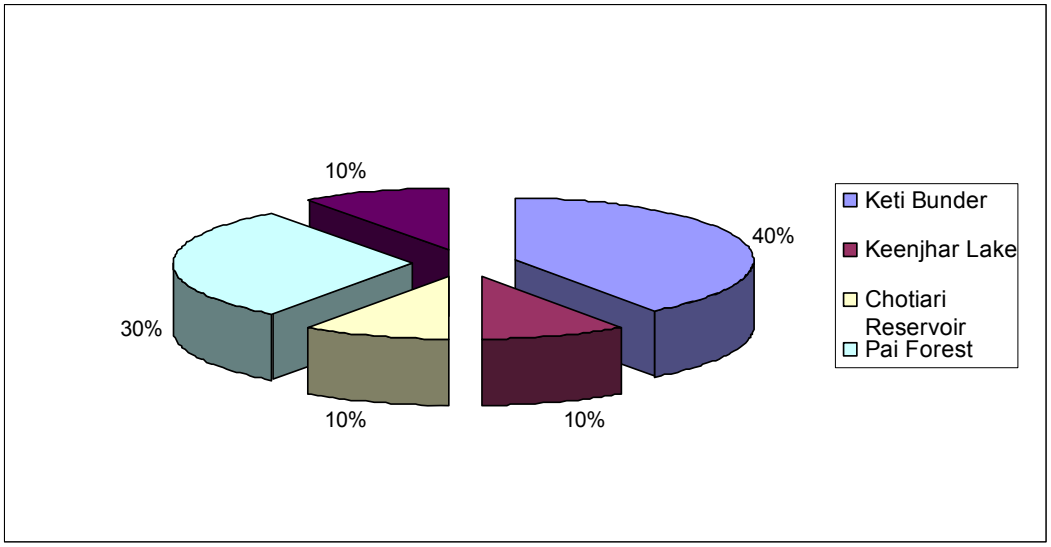
4.4.3.1 Summer survey

The following table **(Table 61)** shows the biodiversity index for each. This is also graphically shown in **Figure 41** as a pie-graph

Table 61 – 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 41 – Biodiversity Index of bird species during summer across all sites



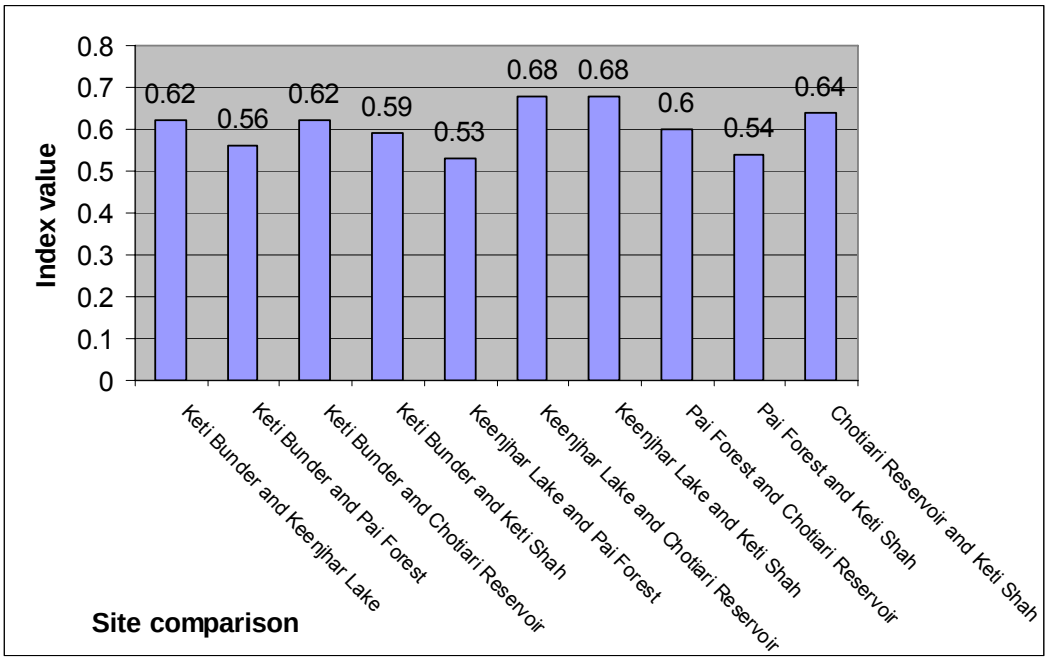
It can be inferred the biodiversity runs (highest first) from Keti Bunder >Pai Forest >Keenjhar Lake> Chotiari Reservoir>Shah Belo.

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 42** 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 42 – Similarity Index for birds recorded during summer across all sites

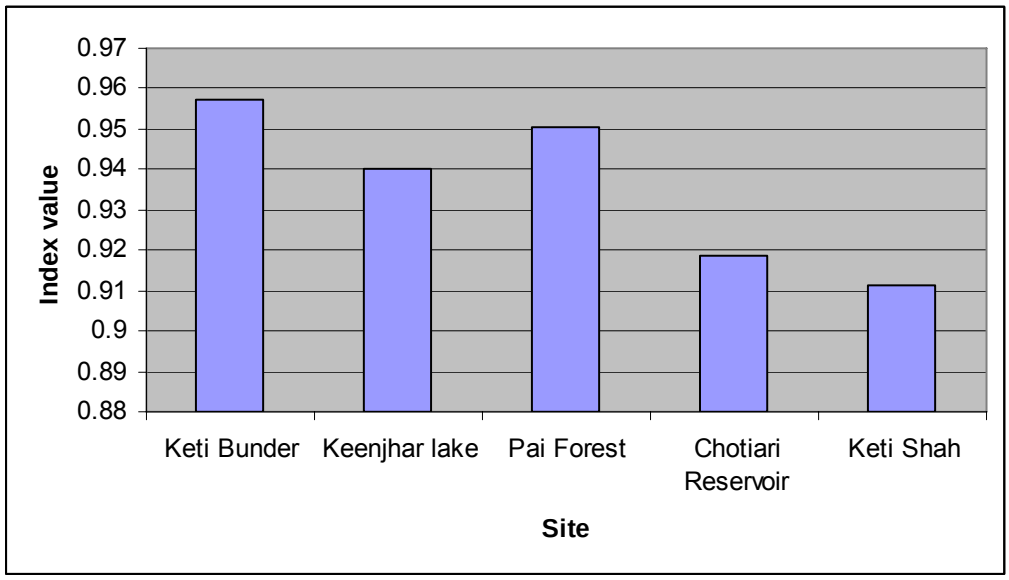


Finally coming to the biodiversity index, **Table 62** shows the indexes for each site and **Figure 43** gives a graphical portrayal of the same figures.

Table 62 - 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 43 – 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

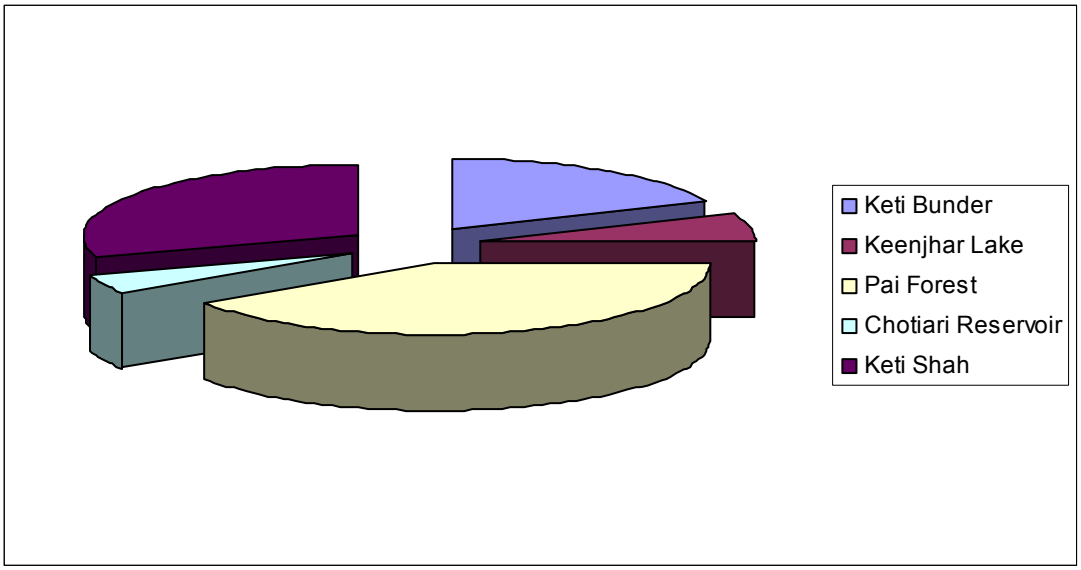
4.4.3.2 Winter surveys

Table 63 and **Figure 44** show the biodiversity index for winter results at Keenjhar Lake.

Table 63 – 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 44 – 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:

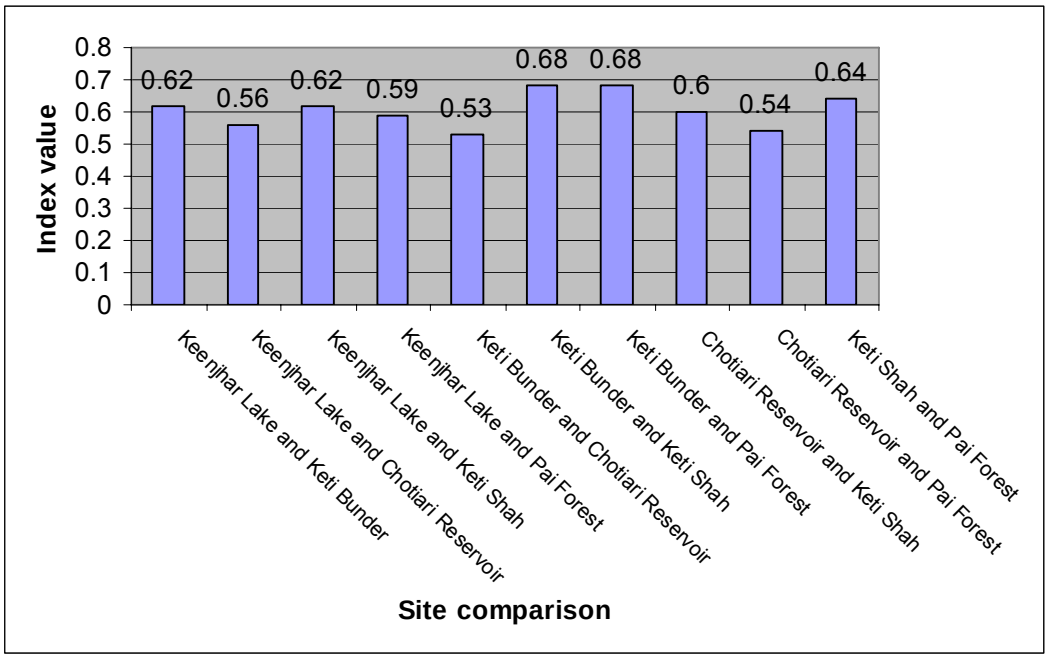
Pai Forest > Keti Shah > Keti Bunder> Keenjhar lake > Chotiari Reservoir

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 45** 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 45 – 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:

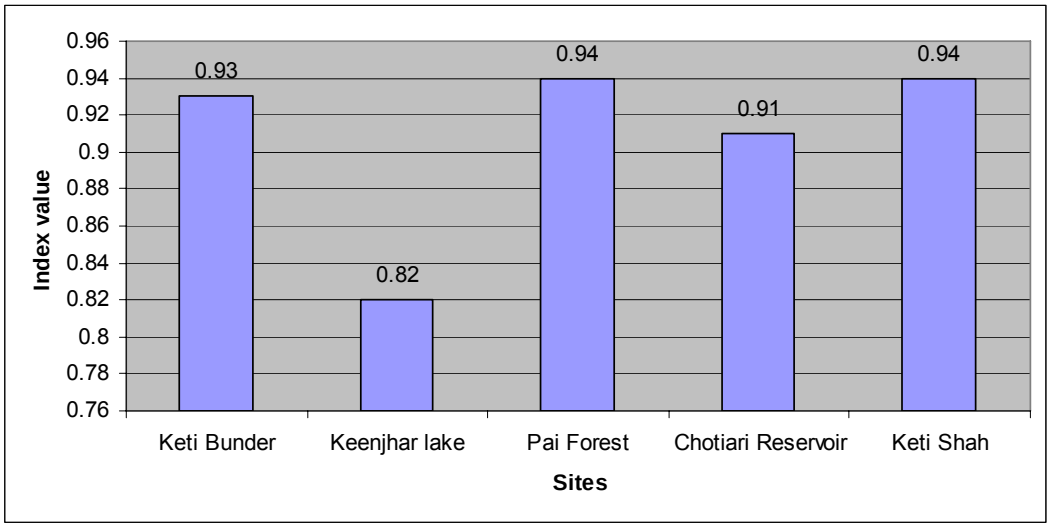
Keenjhar lake -Chotiari Wetlands Complex and Keenjhar- Pai Forest **>** Shah Belo-Pai Forest **>** Chotiari Wetlands Complex- Shah Belo > Keenjhar lake- Keti Bunder> Keenjhar lake- Shah Belo**>** Keti Bunder- Pai Forest> Keti Bunder- Shah Belo > Keti Bunder- Chotiari Wetlands Complex > Chotiari Wetlands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

Finally coming to the diversity index for the sites, **Table 64** and **Figure 46** show the Simpson's index for all the sites during winter.

Table 64 – 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 46 – 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

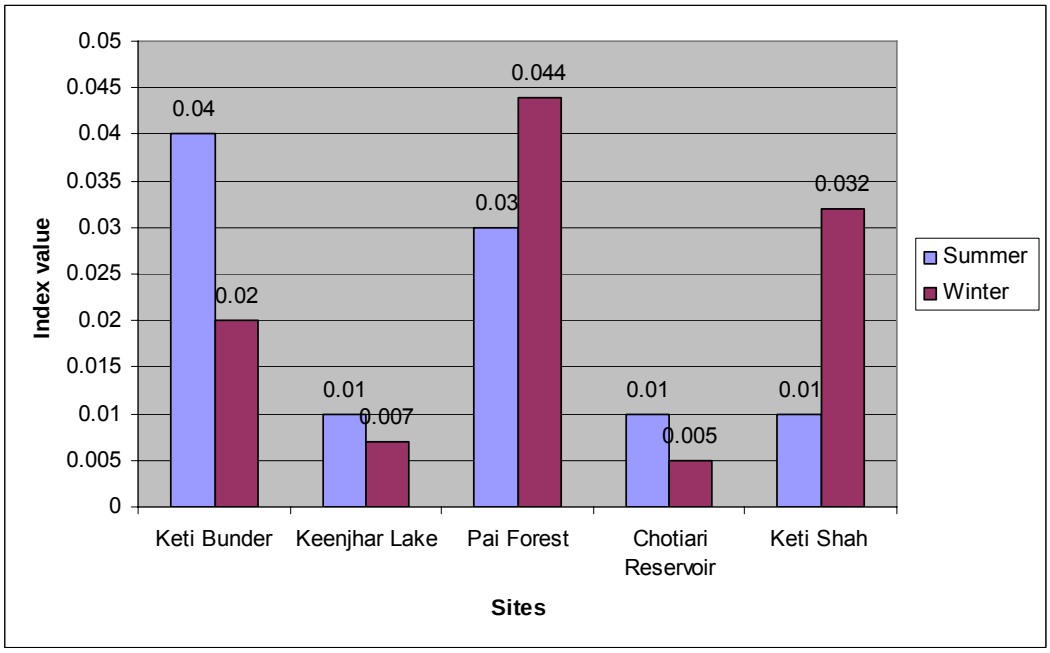
The following table and figures compare the biodiversity index, similarity and Simpson's index over the sites and over the season.

Table 65 and **Figure 47** show the biodiversity index over site and season

Table 65 – 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 47 – Biodiversity indexes for all sites over summer and winter

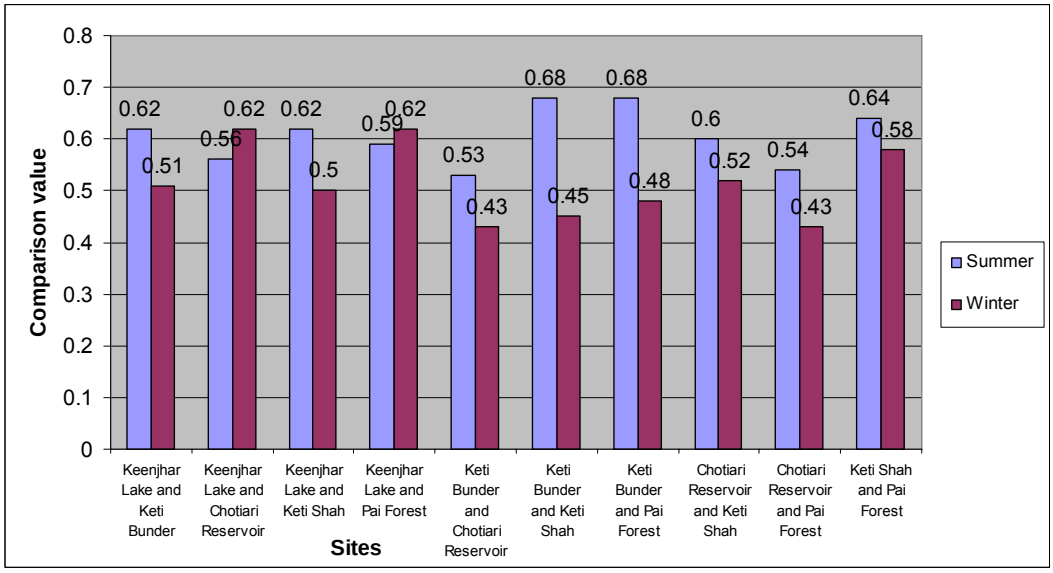


As can be seen in **Figure 47**, diversity is quite changeable over time and space. Pai Forest has the highest diversity in winter whereas Keti Bunder had the highest diversity in summer. Chotiari Reservoir is thought to be the most diverse site under the Indus for All Programme. However it is on par 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 48 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

Figure 48 – Similarity index between sites and over season



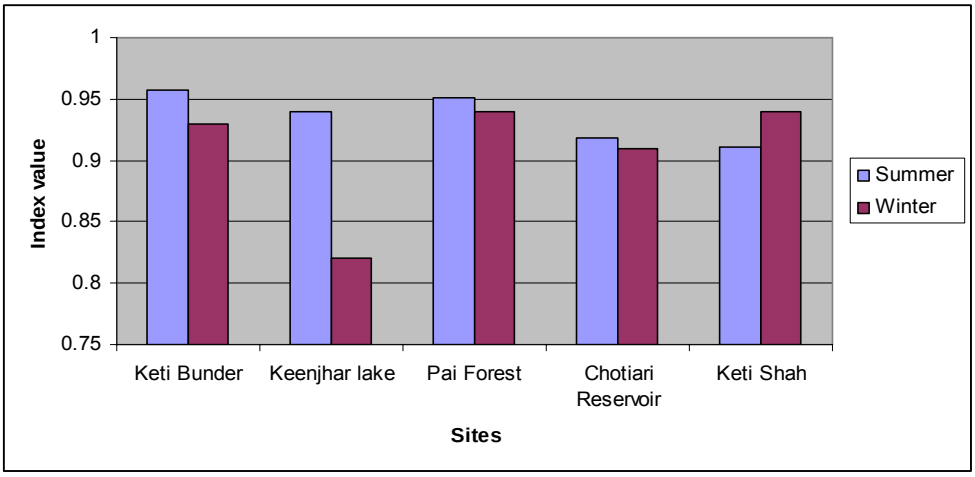
As with the diversity index, there is significant variation over winter and summer seasons. In summer there is more similarity with Keti Bunder – Keti Shah and Keti Bunder – Pai Forest whereas in winter the similarity lies in Keenjhar Lake – Pai Forest and Keenjhar Lake – Chotiari Reservoir. Again this 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.

The following **Table 66** and **Figure 49** show the Simpson's index over sites and season.

Table 66 – 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 49 – 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.

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 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 50 below**). This may be due to better water quality and lack of salinity which was observed in the summer months.

Figure 50 – summer and winter comparison of the number of species collected in the four sites

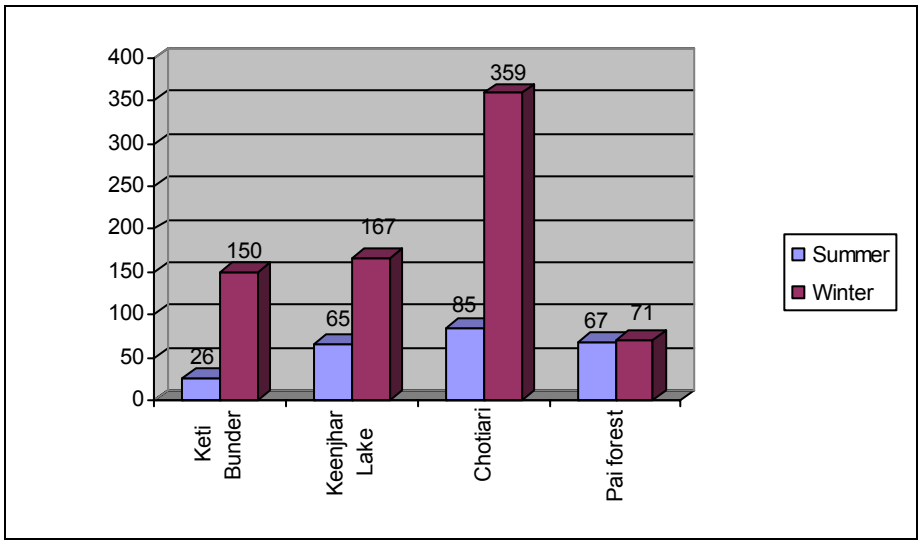


Table 67 – Comparison of phylum during the summer and winter survey in all four sites.

S.no	Class	Keti Bunder		Keenjhar Lake		Chotiari		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 Marine 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 account for marine fisheries in the Keti Bunder report.

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 (Table 2). 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. The other parameters given in Table 2 were within NEQs limits.

  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 (Table 3). 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. Other parameters as reflected in Table 4 are within WHO safe limits.

- **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, Id 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.

- **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 68 – water quality parameters over site and season

	Keti Bunder		Keenjhar Lake		Chotiari		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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